

TTM60A ***TTM61A*** **SERVICE MANUAL**

P/N: M2-77624-3010



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808

Section

TABLE OF CONTENTS

Introduction	1-1
Safety.....	2-1
General Service Information	3-1
Overhaul.....	4-1
Troubleshooting	5-1

TABLE OF CONTENTS

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Section 1

INTRODUCTION

This manual gives specific instructions for the proper repair on TTM transmissions.

Please follow the procedures carefully to ensure quality service.

Tuff Torq recommends that you read this *Service Manual* completely before starting with repairs, as some of the procedures described are rather complex.

Along with standard tools, Tuff Torq recommends the use of special tools, necessary to perform repairs correctly.

Tuff Torq products are continuously undergoing improvement. This *Service Manual* has been checked carefully in order to avoid errors. However Tuff Torq is not liable, for any misrepresentations, errors of description or omissions. Contact an authorized Tuff Torq marine dealer or distributor for any questions you have regarding this *Service Manual*.

This manual is a living document. Periodic manual revisions are published to document product improvements and changes. This practice ensures the manual has the most current information.

Revision Control Table

At times the revision involves inserting additional pages in one or more sections. Insert the new information and only the **Revision Control Table** should be replaced.

This method of revision control represents the most cost-effective solution to providing fresh, updated information as needed.

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Section 2

SAFETY

	Page
Safety Precautions	2-4
Before You Service.....	2-4
Precautions for Safe Servicing	2-4

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Tuff Torq is concerned for your safety and the condition of your marine gear. Safety statements are one of the primary ways to call your attention to the potential hazards associated with Tuff Torq marine gear. Follow the precautions listed throughout the manual before operation, during operation and during periodic maintenance procedures for your safety, the safety of others and to protect the performance of your marine gear. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged. Also, if you need to replace a part that has a label attached to it, make sure you order the new part and label at the same time.



This safety alert symbol appears with most safety statements. It means attention, become alert, your safety is involved! Please read and abide by the message that follows the safety alert symbol.

CAUTION

Caution (the word “CAUTION” is in black letters with a yellow rectangle behind it) – indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

0000001en

CAUTION

Caution without the safety alert symbol indicates a potentially hazardous situation that can cause damage to the marine gear, personal property and / or the environment or cause the marine gear to operate improperly.

0000001enTrans

DANGER

Danger (the word “DANGER” is in white letters with a red rectangle behind it) - indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. Danger is limited to the most extreme situations.

0000001en

WARNING

Warning (the word “WARNING” is in black letters with an orange rectangle behind it) – indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

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SAFETY PRECAUTIONS

Before You Service

CAUTION



NEVER permit anyone to install or operate the marine gear without proper training.

Read and understand this Service Manual before you operate or service the marine gear to ensure that you follow safe servicing practices and maintenance procedures.

- Safety signs and labels are additional reminders for safe service and maintenance techniques.
- See your authorized Tuff Torq marine dealer or distributor for your installation, service and training needs.

0000002enTransSMTT

Precautions for Safe Servicing

 **DANGER****CRUSH HAZARD!**

- Always use lifting equipment with sufficient capacity to lift marine gear.
- Have a helper assist you attaching the marine gear to the hoist.
- NEVER stand under hoisted marine gear. If the hoist mechanism fails, the marine gear will fall on you, causing serious injury or death.
- NEVER support marine gear with equipment not designed to support the weight of the marine gear such as wooden pieces, blocks or by only using a jack.
- Failure to comply will result in death or serious injury.

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⚠ DANGER**FIRE HAZARD!**

- ALWAYS keep fire extinguishers handy in case of fire. Clearly indicate the location of the fire extinguishers with a safety sign.
- ALWAYS ensure that the type of fire extinguishers are appropriate for material that might catch fire. Check with local authorities.
- ALWAYS have all fire extinguishers checked periodically for proper operation and / or readiness.
- ALWAYS post evacuation routes prominently. Periodically conduct fire drills.
- ALWAYS ensure that appropriate fire detection and extinguishing equipment are installed and checked periodically for proper operation. Check with local authorities.
- Failure to comply will result in death or serious injury.

0000018en

⚠ WARNING**SUDDEN MOVEMENT HAZARD!**

- When you install the “emergency nut” the boat will move forward as soon as you start the engine! Make sure the area is clear before you start the engine.
- Failure to comply could result in death or serious injury.

0000025en

⚠ WARNING**SEVER HAZARD!**

- Keep hands and other body parts away from moving / rotating parts such as the flywheel or PTO shaft.
- Wear tight-fitting clothing and keep your hair short or tie it back while the engine is running.
- Remove all jewelry before you operate or service the marine gear.
- NEVER start the engine in gear. Sudden movement of the engine and / or vessel could cause death or serious personal injury.
- NEVER operate the marine gear without the guards in place.
- Before you start the engine make sure that all bystanders are clear of the area.
- Keep children and pets away while the engine is operating.
- Check before starting the engine that any tools or shop rags used during maintenance have been removed from the area.
- Failure to comply could result in death or serious injury.

0000002enTrans

⚠ WARNING**ALCOHOL AND DRUG HAZARD!**

- NEVER operate the vessel while you are under the influence of alcohol or drugs.
- NEVER operate the vessel when you are feeling ill.
- Failure to comply could result in death or serious injury.

0000004enTrans

⚠ WARNING**EXPOSURE HAZARD!**

- ALWAYS wear personal protective equipment such as gloves, work shoes, eye and hearing protection as required by the task at hand.
- NEVER wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing when you are working near moving / rotating parts such as the cooling fan, flywheel or PTO shaft.
- ALWAYS tie back long hair when you are working near moving / rotating parts such as a cooling fan, flywheel, or PTO shaft.
- NEVER operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the alert signals.
- Failure to comply could result in death or serious injury.

0000005en

⚠ WARNING**SHOCK HAZARD!**

- ALWAYS turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.
- Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. ALWAYS keep the connectors and terminals clean.
- Failure to comply could result in death or serious injury.

0000009en

⚠ WARNING**SEVER HAZARD!**

- Stop the engine before you begin to service the marine gear.
- Secure the propeller so it will not turn before you service the marine gear.
- NEVER leave the key in the key switch when you are servicing the marine gear. Someone may accidentally start the engine and not realize you are servicing it. This could result in a serious injury.
- If you must service the marine gear while it is operating, remove all jewelry, tie back long hair, and keep your hands, other body parts and clothing away from moving / rotating parts.
- Failure to comply could result in death or serious injury.

0000010enTrans

⚠ WARNING**BURN HAZARD!**

- If you must drain the marine gear oil while it is still hot, stay clear of the hot marine gear oil to avoid being burned.
- ALWAYS wear eye protection.
- Failure to comply could result in death or serious injury.

0000011enTrans

⚠ WARNING**BURN HAZARD!**

- **ALWAYS** wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and cause burns.
- Failure to comply could result in death or serious injury.

0000016en

⚠ WARNING**SEVER HAZARD!**

- **NEVER** service the marine gear while under tow or if the engine is running at idle speed. The propeller may rotate under these circumstances.
- Failure to comply could result in death or serious injury.

0000021en

⚠ WARNING**SEVER HAZARD!**

- If the vessel has more than one engine, **NEVER** service a marine gear if either of the engines are running. In multi-engine configurations the propeller for an engine that is shut down may rotate if any of the other engines are running.
- Failure to comply could result in death or serious injury.

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⚠ WARNING**SUDDEN MOVEMENT HAZARD!**

- Shift the marine gear into the **NEUTRAL** position any time the engine is at idle.
- Failure to comply could result in death or serious injury.

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⚠ WARNING**BURN HAZARD!**

- Keep your hands, and other body parts, away from hot engine and marine gear surfaces such as the muffler, exhaust pipe, turbocharger (if equipped), engine block and marine gear chassis during operation and shortly after you shut down the engine. These surfaces are extremely hot while the engine is operating and could seriously burn you.
- Failure to comply could result in death or serious injury.

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⚠ WARNING

Use heat resistant gloves when handling the hot housing halves and outer races.

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⚠ WARNING**FUME / BURN HAZARD!**

- ALWAYS read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.
- Failure to comply could result in death or serious injury.

0000014en

⚠ WARNING

Use heat resistant gloves when handling the hot housing halves and outer races.

0000102en

⚠ WARNING**BURN HAZARD!**

- Handle heated thrust collars with heat resistant gloves!
- Failure to comply could result in death or serious injury.

0000103en

⚠ WARNING**BURN HAZARD!**

- Handle heated tapered roller bearings with heat resistant gloves!
- Failure to comply could result in death or serious injury.

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⚠ WARNING**BURN HAZARD!**

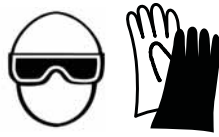
- Handle heated tapered roller bearing outer races with heat resistant gloves!
- Failure to comply could result in death or serious injury.

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⚠ WARNING**BURN HAZARD!**

- Handle heated output coupling with heat resistant gloves!
- Failure to comply could result in death or serious injury.

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⚠ CAUTION**COOLANT HAZARD!**

- Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.
- Failure to comply may result in minor or moderate injury.

0000005en

⚠ CAUTION**FLYING OBJECT HAZARD!**

- ALWAYS wear eye protection when servicing marine gear and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.
- Failure to comply may result in minor or moderate injury.

0000003enTrans

⚠ CAUTION**SLIPPING AND TRIPPING HAZARD!**

- Ensure that adequate floor space is set aside for servicing marine gear. The floor space must be flat and free of holes.
- Keep floor free of dust, mud, spilled liquids and parts to help prevent slipping and tripping.

Failure to comply may result in minor or moderate injury.

0000022en

⚠ CAUTION**POOR LIGHTING HAZARD!**

- Ensure that the work area is adequately illuminated.
- Use task lighting to illuminate areas that need additional illumination.
- Always place wire cage on portable safety lamps.
- Failure to comply may result in minor or moderate injury.

0000023en

⚠ CAUTION**TOOL HAZARD!**

- Use tools appropriate for the task at hand.
- Use the correct size tool for loosening or tightening machine parts.
- Failure to comply may result in minor or moderate injury.

0000024en

CAUTION

Observe the following environmental operating conditions to maintain marine gear performance and avoid premature marine gear wear:

- Avoid operating in extremely dusty conditions.
- Avoid operating in the presence of chemical gases or fumes.

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CAUTION

If any problem is noted during the visual check, **ALWAYS** take the necessary corrective action before you operate the engine.

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CAUTION

NEVER hold the key in the **START** position for longer than 15 seconds or the starter motor will overheat.

0000007en

CAUTION

The illustrations and descriptions of optional equipment in this manual, such as the operator's console, are for a typical marine gear installation. Refer to the documentation supplied by the optional equipment manufacturer for specific operation and maintenance instructions.

0000018enTrans

CAUTION

Observe the following environmental operating conditions to maintain marine gear performance and avoid premature marine gear wear:

- **NEVER** run the marine gear if the ambient temperature is above +45°C (+113°F) or below -15°C (+5°F).
- If the ambient temperature exceeds +45°C (+113°F) the marine gear may overheat and cause the marine gear oil to break down.
- If the ambient temperature falls below -15°C (+5°F) rubber components such as gaskets and seals will harden causing premature marine gear wear and damage.
- Contact your authorized Tuff Torq marine dealer or distributor if the marine gear will be operated in either temperature extreme.

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CAUTION

- Only use the marine gear oil specified. Other marine gear oils may affect warranty coverage, cause internal marine gear components to seize and / or shorten marine gear life.
- Prevent dirt and debris from contaminating marine gear oil. Carefully clean the oil plug and dipstick and the surrounding area before you remove either one.
- NEVER mix different types of marine gear oil. This may adversely affect the lubricating properties of the marine gear oil.
- NEVER overfill. Overfilling may result in internal damage.

000005enTrans

CAUTION

The correct level of marine gear oil is very important for proper marine gear function:

- Check the marine gear for the proper amount of marine gear oil before you start the engine for the first time.
- Running the engine with insufficient oil level in the marine gear will cause damage to internal marine gear components.
- NEVER overfill the marine gear with marine gear oil. An excessive oil level may cause leakage at the shaft seals and the marine gear breather, and raise the operating temperature considerably.
- ALWAYS keep the oil level between upper and lower lines on the dipstick.

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CAUTION

Before operating the engine, check marine gear oil level.

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CAUTION

- During normal operation, the marine gear should only be shifted with the engine at idle.
- Shifting at higher engine speed will damage the marine gear.

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CAUTION

If the marine gear oil temperature is too high, stop engine immediately and check the marine gear oil level and check the oil cooler for proper coolant and water flow.

Have the marine gear serviced by an authorized Tuff Torq marine dealer or distributor before you start the engine again.

0000074enTT

CAUTION

After you add marine gear oil, run the engine for several minutes and shut it down. Wait at least 10 minutes to check the marine gear oil level. This allows the oil to drain back into the sump, otherwise, you may overfill the marine gear with oil.

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CAUTION**New Marine Gear Break-In:**

- On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper marine gear function and marine gear oil leaks.
- During the break-in period, carefully observe marine gear indicators (if any) for proper marine gear function.
- During the break-in period, check the marine gear oil levels frequently.

0000011enTrans

CAUTION

NEVER engage the starter motor while the engine is running. This may damage the starter motor pinion and / or ring gear.

0000012en

CAUTION

- **NEVER** attempt to modify the marine gear's design or safety features.
- Failure to comply may impair the marine gear's safety and performance characteristics and shorten the marine gear's life. Any alterations to this marine gear may affect the warranty coverage of your marine gear.

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CAUTION

- **ALWAYS** be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- **NEVER** dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

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CAUTION

Protect the electric components from damage when you use steam or use high-pressure water to clean the engine or marine gear.

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CAUTION

ALWAYS stop the engine immediately if any indicator illuminates during engine operation. Determine the cause and repair the problem before you continue to operate the engine.

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CAUTION

Establish a periodic maintenance plan according to the engine application and make sure you perform the required periodic maintenance at intervals indicated. Failure to follow these guidelines will impair the marine gear's safety and performance characteristics, shorten the marine gear's life and may affect the warranty coverage on your marine gear.

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CAUTION

Always tighten to the specified torque. Loose parts can cause equipment damage or cause it to operate improperly.

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CAUTION

Keep dirt out of marine gear housing. Dirt may shorten the life of the marine gear and cause it to operate improperly.

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CAUTION

If you have more than one engine, you cannot shift the marine gear into the "B" position after you install the "emergency nut."

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CAUTION

It is important to perform daily checks. Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor machine performance and helps extend the life of the marine gear.

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CAUTION

Only use replacement parts specified. Other replacement parts may affect warranty coverage, cause internal marine gear components to seize, or shorten marine gear life.

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Section 3

GENERAL SERVICE INFORMATION

	Page
Marine Gear System	3-4
Specifications	3-5
Marine Gear Component Location	3-6
Case Plate Component Location.....	3-8
Hydraulic Diagram	3-10
Shifting Pressure	3-11
Function Test.....	3-11
Required Tests:	3-11

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This marine gear has a built-in wet type multi-disc clutch and is operated by the oil pressure of the hydraulic pump.

The major components are:

- damper
- input shaft assembly
- support shaft assembly
- output shaft assembly
- hydraulic pump
- housing

The lube oil for each of the parts is distributed by the hydraulic pump in a forced lubrication system.

When the forward / reverse changing valve lever is moved, oil pressure is applied to move the clutch to the FORWARD or REVERSE position.

The clutch for clockwise rotation of O / P is fitted to the input shaft, and the clutch for counterclockwise rotation of O / P is fitted to the support shaft.

The marine gear oil (lube oil) is cooled by a multi-pipe marine gear oil cooler.

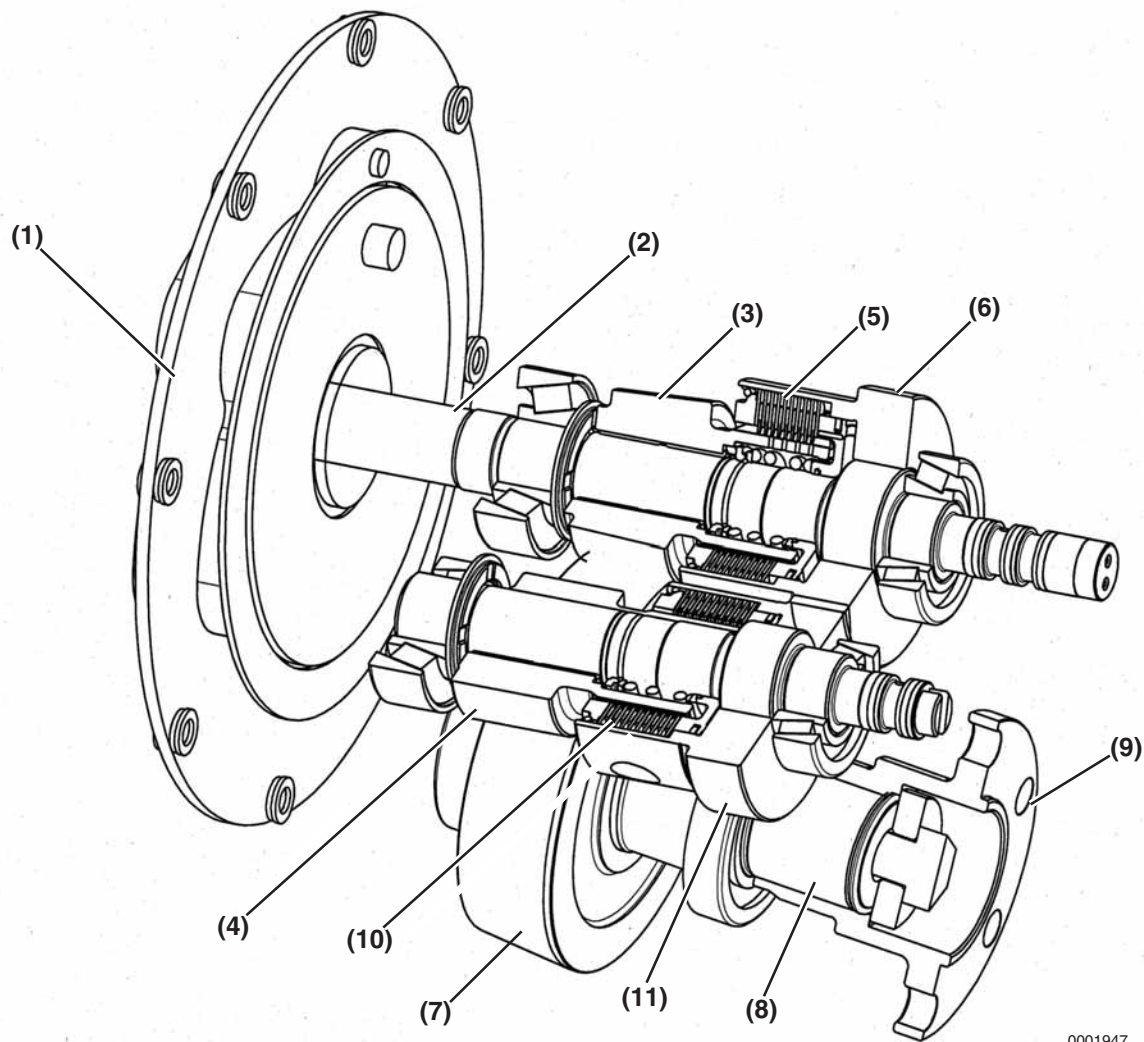
MARINE GEAR SYSTEM

Marine gear rotation with shift lever in position A:

Damper (1)→Input Shaft (2)→Drive Gear (3)→Input Shaft Clutch (5)→Input Pinion (6)→Output Gear (7)→Output Shaft (8)→Output Coupling (9)

Marine gear rotation with shift lever in position B:

Damper (1)→Input Shaft (2)→Drive Gear (3)→Driven Gear (4)→Support Shaft Clutch (10)→Support Pinion (11)→Output Gear (7)→Output Shaft (8)→Output Coupling (9)



0001947

Figure 3-1

SPECIFICATIONS

Items		TTM60A	TTM61A	Remarks
Type		Down Angle Hydraulic		
Angle		8°		
Maximum Input Torque		960 N·m (708 ft-lb)	1070 N·m (789 ft-lb)	
Input Speed		700 - 3300 min ⁻¹ (rpm)		
Reduction Ratio (F / R)		2.43 / 2.43		
		2.04 / 2.04		
		1.55 / 1.55		
Direction of Rotation	I / P	Counterclockwise		Viewed from Stern
	O / P	Clockwise (Recommended) or Counterclockwise		
Shift		Mechanical Cable	Electrical	
Lubrication		Forced Lubrication		
Oil Type		API (American Petroleum Institute) Service Grade Class: CF		Never use multi-grade oil or mix oil types. Single-grade oil must be used.
		Viscosity: SAE 30		
Oil Quantity (Effective)		2.8 L (0.5 L) 3.0 qt (0.5 qt)		
Dimensions	L	286.0 mm (11.3 in.)		SAE #3
	A	145.4 mm (5.7 in.)		
	W	390 mm (15.4 in.)		
Clutch Size		SAE 11.5 in.		
Dry Mass	Marine Gear	58.0 kg (127.9 lb)		Without Mounting Feet, Marine Gear Oil Cooler, Damper
	Mounting Feet	2.3 x 2 kg (5 x 4 lb)		
	Marine Gear Oil Cooler	7.0 kg (15.4 lb)	8.0 kg (17.64 lb)	With Bracket, Hoses, Fittings
	Damper	7.5 kg (16.5 lb)		

MARINE GEAR COMPONENT LOCATION

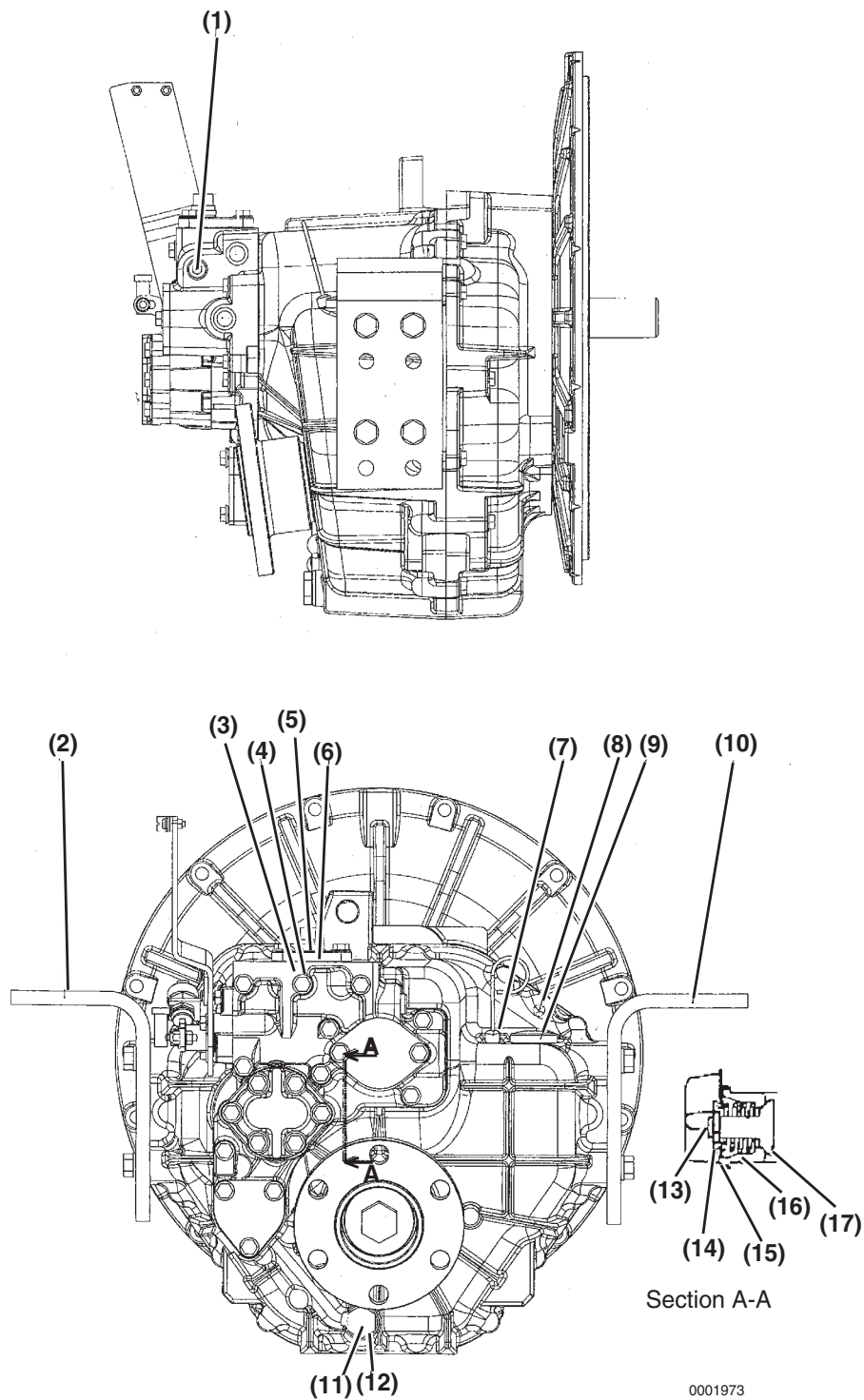


Figure 3-2

- 1 – Plug
- 2 – Mounting Foot
- 3 – Upper Cover
- 4 – Gasket
- 5 – Plug
- 6 – O-ring
- 7 – Dipstick
- 8 – Parallel Pin
- 9 – Breather
- 10 – Mounting Foot
- 11 – Magnet Plug
- 12 – Seal Washer
- 13 – Spring Pin
- 14 – Spring Retainer
- 15 – Spring
- 16 – 2nd Relief Sheet
- 17 – 2nd Relief Valve

CASE PLATE COMPONENT LOCATION

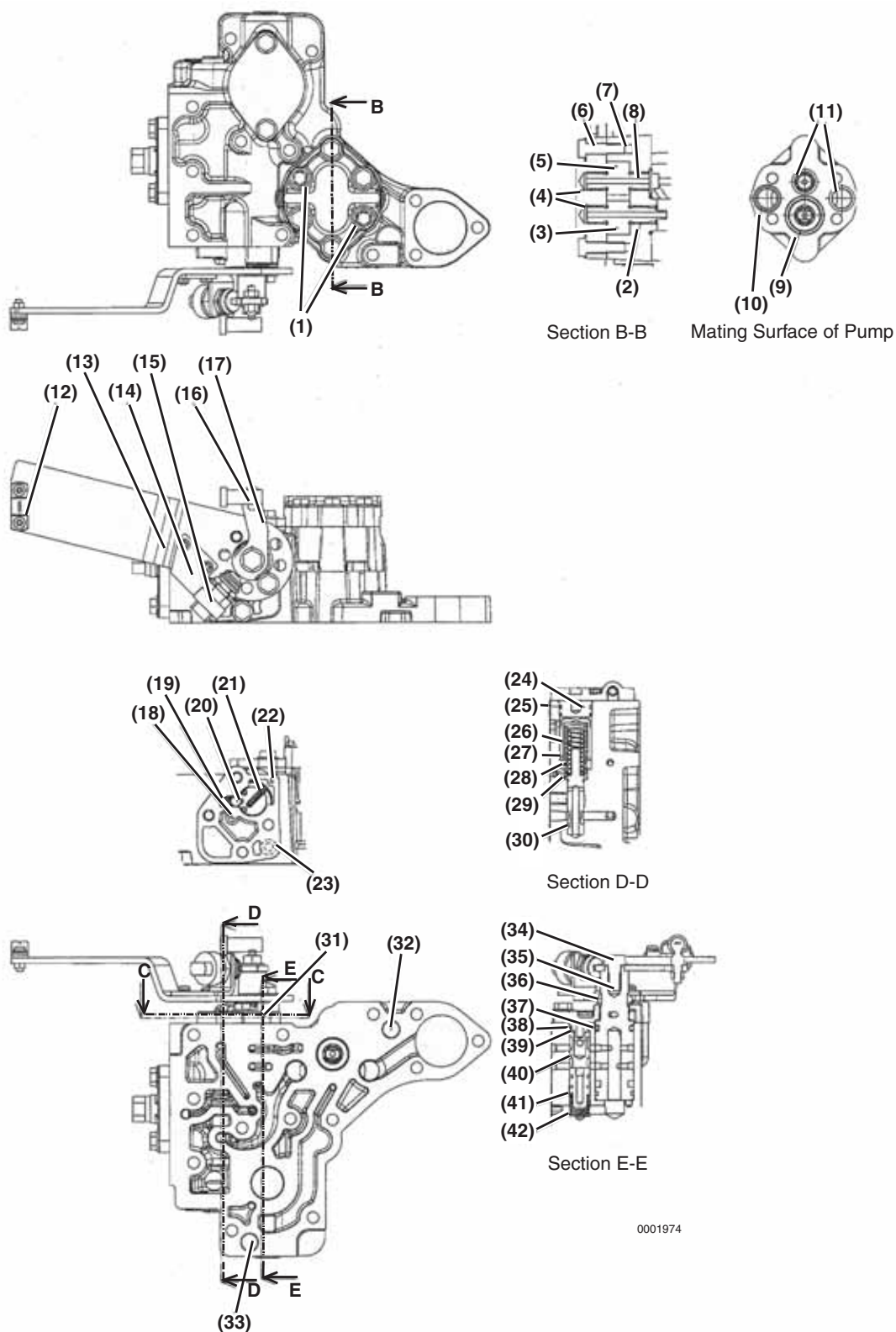
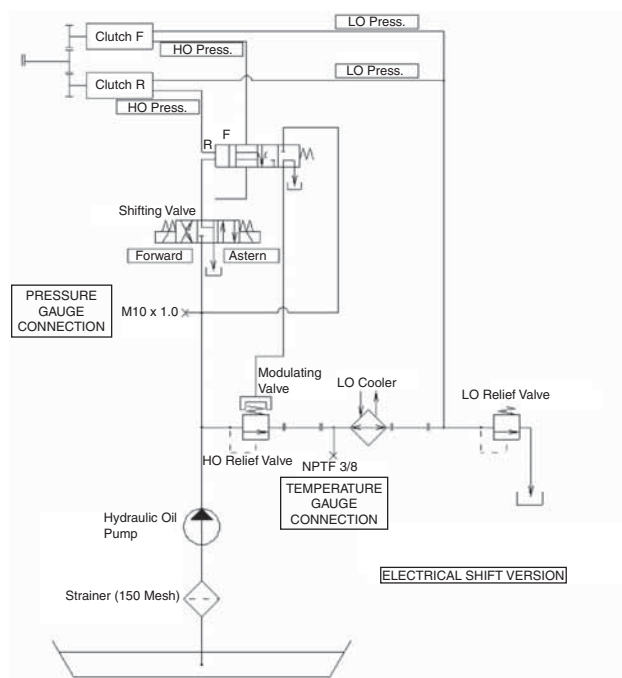
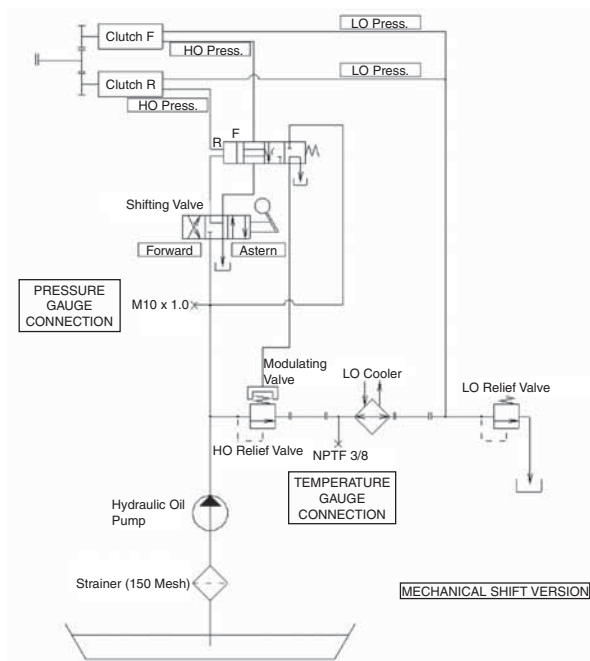


Figure 3-3

- 1 – Pin
- 2 – Bearing
- 3 – Pump Drive Gear
- 4 – Bearing
- 5 – Pump Driven Gear
- 6 – Pump Cover
- 7 – Pump Body
- 8 – Bearing
- 9 – O-ring
- 10 – O-ring
- 11 – O-ring
- 12 – Clamp
- 13 – Wire Bracket
- 14 – Switch Support
- 15 – Safety Switch
- 16 – Ball Joint
- 17 – Shifting Lever
- 18 – Parallel Pin
- 19 – Spring
- 20 – Ball
- 21 – Pin
- 22 – Parallel Pin
- 23 – O-ring
- 24 – Cover
- 25 – O-ring
- 26 – Spring
- 27 – Modulating Valve
- 28 – Spring
- 29 – Shim
- 30 – HO Relief Valve
- 31 – Cover
- 32 – Parallel Pin
- 33 – Parallel Pin
- 34 – Bolt
- 35 – Shifting Valve
- 36 – V-ring
- 37 – O-ring
- 38 – O-ring
- 39 – Cover
- 40 – Pilot Valve
- 41 – Throttle Valve
- 42 – Spring

HYDRAULIC DIAGRAM



0001969

Figure 3-4

SHIFTING PRESSURE

Shifting pressure is hydraulic pressure. Shifting pressure must be between min. and max. line in the below performance graph at any time. If not, See *Troubleshooting on page 5-1*.

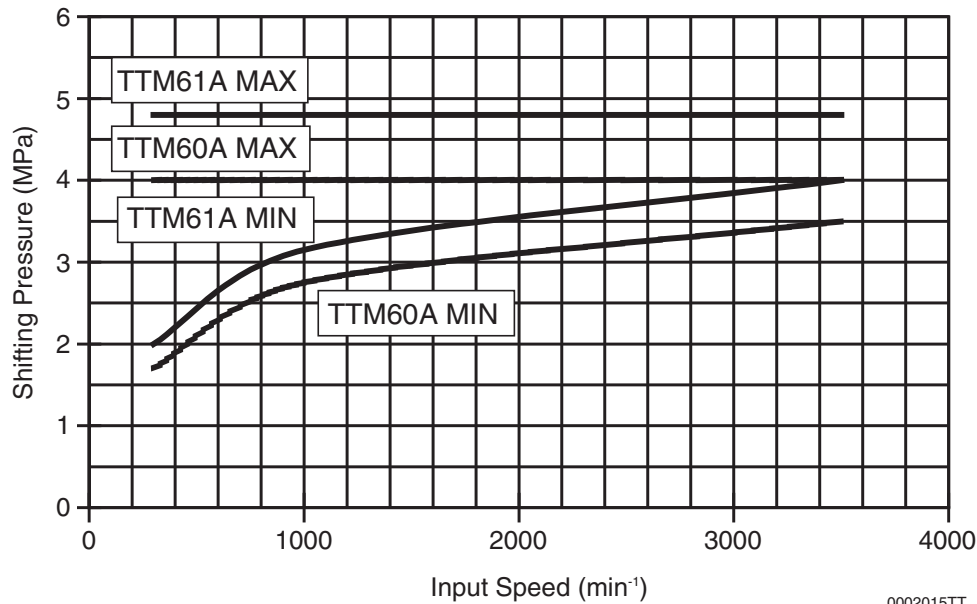


Figure 3-5

FUNCTION TEST

Perform a function test after servicing the marine gear. Be sure the marine gear is filled with oil.

This test can be performed on a bench test rig, or in a boat.

If a marine gear oil cooler is not installed, connect a hydraulic hose between the inlet and outlet of the hydraulic pump.

Required measuring instruments:

- Pressure gauge - 0-5 MPa (0 - 750 psi), with connecting thread M10 x 1.25.
- Temperature gauge - 0-120°C (0 – 250°F), connecting thread 3/8"-18 NPTF.

See *Hydraulic Diagram on page 3-10* for pressure and temperature gauge location.

Required Tests:

1. Fluid leaks
2. Noise emission
3. Direction of rotation, LH / RH
4. Lube oil temperature
5. Shifting pressure
6. Neutral performance
7. Shifting performance

The function test should be carried out as follows:

No.	Engine Speed	Shift Lever Position A: Lever is raised B: Lever is lowered	Duration	Test
1	800 - 1000 rpm	neutral	5	1, 2
2	600 - 800 rpm (idling speed)	A<->B position repeatedly	-	1, 2, 3, 6, 7
3	1500 - 2500 rpm	B position	*	1, 2, 4
4	600 - 800 rpm (idling speed)	A<->B position repeatedly	-	1, 2, 3, 6, 7
5	idling - maximum speed	A position	-	1, 2, 5**
6	600 - 800 rpm (idling speed)	A->B position	-	1, 2
7	idling - maximum speed	B position	-	1, 2, 5**

*Until oil temperature of 75 - 80°C (167 - 176°F) has been reached.

**At different speeds.

Note: See Shifting Pressure on page 3-11 and Standard Valve of Performance below.

Standard Value of Performance

Items			TTM60A	TTM61A	Remarks
Neutral Performance (Time Until Stopping)			≤ 20 seconds		Oil Temperature 30°C (86°F) Idling Speed
Shifting	Time to Engage		≤ 1.0 seconds		Oil Temperature 30°C (86°F) Idling Speed
Oil Temperature			≤ 90°C (194°F)		
Oil Pressure	HO	Maximum	≤ 4.09 MPa (593 psi)	≤ 4.82 MPa (699 psi)	Oil Temperature 30°C (86°F) 3300 rpm
		Setting	3.72 ± 0.05 MPa (539 ± 7 psi)	4.38 ± 0.05 MPa (635 ± 7 psi)	Oil Temperature 60°C (140°F) 3300 rpm
		Minimum	≥ 1.86 MPa (270 psi)	≥ 2.19 MPa (318 psi)	Oil Temperature 60°C (140°F) 700 rpm
	LO	Maximum	≤ 0.30 MPa (44 psi)	≤ 0.65 MPa (94 psi)	Oil Temperature 30°C (86°F) 3300 rpm
		Setting	0.25 ± 0.05 MPa (36 ±7 psi)	0.60 ± 0.05 MPa (87 ±7 psi)	Oil Temperature 60°C (140°F) 3300 rpm
		Minimum	≥ 0.01 MPa (1.5 psi)		Oil Temperature 60°C (140°F) 700 rpm

Section 4

OVERHAUL

	Page
Before You Begin Servicing	4-3
Before You Operate.....	4-3
During Operation and Maintenance.....	4-4
Past Inspections for the Engine and the Marine Gear.....	4-14
Special Service Tools.....	4-15
Measuring instruments	4-19
Standard Tools	4-20
Torque Chart	4-21
Marine Gear Component identification.....	4-22
Marine Gear Sectional View.....	4-24
Case Plate Component Identification	4-26
Preparing for Overhaul	4-28
Disassembly of Marine Gear	4-28
Draining Transmission Oil	4-29
Removal of Oil Filter	4-30
Removal of Dipstick.....	4-30
Removal of Output Coupling	4-30
Removal of Hydraulic Oil Pump.....	4-31
Removal of Case Plate.....	4-31
Removal of Valves.....	4-32
Removal of Mounting Feet	4-33
Removal of Oil Seals	4-37
Removal of Tapered Roller Bearings	4-38
Removal of Clutch pack.....	4-39
Cleaning Of Marine Gear	4-42

OVERHAUL

Inspection of Marine Gear	4-42
Cases	4-42
Bearings	4-42
Shafts and Gears	4-42
Reassembly of Marine Gear.....	4-43
Reassembly of Input Shaft and Support Shaft	4-43
Reassembly of Pinion Gear Assemblies	4-45
Reassembly of Thrust Collars	4-45
Reassembly of Tapered Roller Bearings Onto Input and Support Shafts.....	4-46
Reassembly of Seal Rings	4-47
Reassembly of Tapered Roller Bearing Onto Output Shaft	4-47
Adjustment of Gear Backlash.....	4-48
Reassembly of Taper Roller Bearing Outer Races Into Case B	4-49
Reassembly of Oil Suction Cover (If Removed Earlier)	4-50
Reassembly of Oil Seals	4-50
Measuring Bearing Clearance / Adjusting Bearing Preload	4-51
Reassembly of Gear Set Into Housing	4-52
Reassembly of Tapered Roller Bearings Outer Races Into Case A	4-52
Final Assembly of Cases	4-53
Reassembly of Mounting Flange	4-54
Reassembly of Valves	4-54
Reassembly of Case Plate	4-55
Reinstall Oil Filter	4-55
Reinstall Hydraulic Oil Pump	4-56
Reassembly of Output Coupling.....	4-56
Filling Marine Gear With Oil	4-57
Checking Oil Level	4-58
Trial Run.....	4-59

This section of the *Service Manual* describes the procedures for proper repair of the marine gear.

BEFORE YOU BEGIN SERVICING

Before You Operate

CAUTION



NEVER permit anyone to install or operate the marine gear without proper training.

Read and understand this Service Manual before you operate or service the marine gear to ensure that you follow safe servicing practices and maintenance procedures.

- Safety signs and labels are additional reminders for safe service and maintenance techniques.
- See your authorized Tuff Torq marine dealer or distributor for your installation, service and training needs.

0000002enTransSMTT

During Operation and Maintenance

⚠ DANGER**CRUSH HAZARD!**

- Always use lifting equipment with sufficient capacity to lift marine gear.
- Have a helper assist you attaching the marine gear to the hoist.
- NEVER stand under hoisted marine gear. If the hoist mechanism fails, the marine gear will fall on you, causing serious injury or death.
- NEVER support marine gear with equipment not designed to support the weight of the marine gear such as wooden pieces, blocks or by only using a jack.
- Failure to comply will result in death or serious injury.

0000008enTransSM

⚠ DANGER**FIRE HAZARD!**

- ALWAYS keep fire extinguishers handy in case of fire. Clearly indicate the location of the fire extinguishers with a safety sign.
- ALWAYS ensure that the type of fire extinguishers are appropriate for material that might catch fire. Check with local authorities.
- ALWAYS have all fire extinguishers checked periodically for proper operation and / or readiness.
- ALWAYS post evacuation routes prominently. Periodically conduct fire drills.
- ALWAYS ensure that appropriate fire detection and extinguishing equipment are installed and checked periodically for proper operation. Check with local authorities.
- Failure to comply will result in death or serious injury.

0000018en

⚠ WARNING**SUDDEN MOVEMENT HAZARD!**

- When you install the “emergency nut” the boat will move forward as soon as you start the engine! Make sure the area is clear before you start the engine.
- Failure to comply could result in death or serious injury.

0000025en

⚠ WARNING**SEVER HAZARD!**

- Keep hands and other body parts away from moving / rotating parts such as the flywheel or PTO shaft.
- Wear tight-fitting clothing and keep your hair short or tie it back while the engine is running.
- Remove all jewelry before you operate or service the marine gear.
- NEVER start the engine in gear. Sudden movement of the engine and / or vessel could cause death or serious personal injury.
- NEVER operate the marine gear without the guards in place.
- Before you start the engine make sure that all bystanders are clear of the area.
- Keep children and pets away while the engine is operating.
- Check before starting the engine that any tools or shop rags used during maintenance have been removed from the area.
- Failure to comply could result in death or serious injury.

0000002enTrans

⚠ WARNING**ALCOHOL AND DRUG HAZARD!**

- NEVER operate the vessel while you are under the influence of alcohol or drugs.
- NEVER operate the vessel when you are feeling ill.
- Failure to comply could result in death or serious injury.

0000004enTrans

⚠ WARNING**EXPOSURE HAZARD!**

- **ALWAYS** wear personal protective equipment such as gloves, work shoes, eye and hearing protection as required by the task at hand.
- **NEVER** wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing when you are working near moving / rotating parts such as the cooling fan, flywheel or PTO shaft.
- **ALWAYS** tie back long hair when you are working near moving / rotating parts such as a cooling fan, flywheel, or PTO shaft.
- **NEVER** operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the alert signals.
- Failure to comply could result in death or serious injury.

0000005en

⚠ WARNING**SHOCK HAZARD!**

- **ALWAYS** turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.
- Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. **ALWAYS** keep the connectors and terminals clean.
- Failure to comply could result in death or serious injury.

0000009en

⚠ WARNING**SEVER HAZARD!**

- Stop the engine before you begin to service the marine gear.
- Secure the propeller so it will not turn before you service the marine gear.
- NEVER leave the key in the key switch when you are servicing the marine gear. Someone may accidentally start the engine and not realize you are servicing it. This could result in a serious injury.
- If you must service the marine gear while it is operating, remove all jewelry, tie back long hair, and keep your hands, other body parts and clothing away from moving / rotating parts.
- Failure to comply could result in death or serious injury.

0000010enTrans

⚠ WARNING**BURN HAZARD!**

- ALWAYS wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and cause burns.
- Failure to comply could result in death or serious injury.

0000016en

⚠ WARNING**SEVER HAZARD!**

- NEVER service the marine gear while under tow or if the engine is running at idle speed. The propeller may rotate under these circumstances.
- Failure to comply could result in death or serious injury.

0000021en

⚠ WARNING**BURN HAZARD!**

- If you must drain the marine gear oil while it is still hot, stay clear of the hot marine gear oil to avoid being burned.
- ALWAYS wear eye protection.
- Failure to comply could result in death or serious injury.

0000011enTrans

⚠ WARNING**SEVER HAZARD!**

- If the vessel has more than one engine, NEVER service a marine gear if either of the engines are running. In multi-engine configurations the propeller for an engine that is shut down may rotate if any of the other engines are running.
- Failure to comply could result in death or serious injury.

0000022en

⚠ WARNING**SUDDEN MOVEMENT HAZARD!**

- Shift the marine gear into the **NEUTRAL** position any time the engine is at idle.
- Failure to comply could result in death or serious injury.

0000023en

⚠ WARNING**BURN HAZARD!**

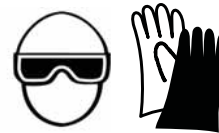
- Keep your hands, and other body parts, away from hot engine and marine gear surfaces such as the muffler, exhaust pipe, turbocharger (if equipped), engine block and marine gear chassis during operation and shortly after you shut down the engine. These surfaces are extremely hot while the engine is operating and could seriously burn you.
- Failure to comply could result in death or serious injury.

0000015enTrans

⚠ WARNING**FUME / BURN HAZARD!**

- **ALWAYS** read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.
- Failure to comply could result in death or serious injury.

0000014en

⚠ CAUTION**COOLANT HAZARD!**

- Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.
- Failure to comply may result in minor or moderate injury.

0000005en

⚠ CAUTION**FLYING OBJECT HAZARD!**

- **ALWAYS** wear eye protection when servicing marine gear and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.
- Failure to comply may result in minor or moderate injury.

0000003enTrans

⚠ CAUTION**POOR LIGHTING HAZARD!**

- Ensure that the work area is adequately illuminated.
- Use task lighting to illuminate areas that need additional illumination.
- Always place wire cage on portable safety lamps.
- Failure to comply may result in minor or moderate injury.

0000023en

⚠ CAUTION**TOOL HAZARD!**

- Use tools appropriate for the task at hand.
- Use the correct size tool for loosening or tightening machine parts.
- Failure to comply may result in minor or moderate injury.

0000024en

⚠ CAUTION**SLIPPING AND TRIPPING HAZARD!**

- Ensure that adequate floor space is set aside for servicing marine gear. The floor space must be flat and free of holes.
- Keep floor free of dust, mud, spilled liquids and parts to help prevent slipping and tripping.

Failure to comply may result in minor or moderate injury.

0000022en

CAUTION

If any problem is noted during the visual check, **ALWAYS** take the necessary corrective action before you operate the engine.

0000021en

CAUTION

NEVER hold the key in the **START** position for longer than 15 seconds or the starter motor will overheat.

0000007en

CAUTION

The illustrations and descriptions of optional equipment in this manual, such as the operator's console, are for a typical marine gear installation. Refer to the documentation supplied by the optional equipment manufacturer for specific operation and maintenance instructions.

0000018enTrans

CAUTION

Observe the following environmental operating conditions to maintain marine gear performance and avoid premature marine gear wear:

- Avoid operating in extremely dusty conditions.
- Avoid operating in the presence of chemical gases or fumes.

0000003enTrans

CAUTION

Observe the following environmental operating conditions to maintain marine gear performance and avoid premature marine gear wear:

- NEVER run the marine gear if the ambient temperature is above +45°C (+113°F) or below -15°C (+5°F).
- If the ambient temperature exceeds +45°C (+113°F) the marine gear may overheat and cause the marine gear oil to break down.
- If the ambient temperature falls below -15°C (+5°F) rubber components such as gaskets and seals will harden causing premature marine gear wear and damage.
- Contact your authorized Tuff Torq marine dealer or distributor if the marine gear will be operated in either temperature extreme.

0000065enKMH60A

CAUTION

- Only use the marine gear oil specified. Other marine gear oils may affect warranty coverage, cause internal marine gear components to seize and / or shorten marine gear life.
- Prevent dirt and debris from contaminating marine gear oil. Carefully clean the oil plug and dipstick and the surrounding area before you remove either one.
- NEVER mix different types of marine gear oil. This may adversely affect the lubricating properties of the marine gear oil.
- NEVER overfill. Overfilling may result in internal damage.

0000005enTrans

CAUTION

The correct level of marine gear oil is very important for proper marine gear function:

- Check the marine gear for the proper amount of marine gear oil before you start the engine for the first time.
- Running the engine with insufficient oil level in the marine gear will cause damage to internal marine gear components.
- NEVER overfill the marine gear with marine gear oil. An excessive oil level may cause leakage at the shaft seals and the marine gear breather, and raise the operating temperature considerably.
- ALWAYS keep the oil level between upper and lower lines on the dipstick.

0000089enKMH60AOM

CAUTION

Before operating the engine, check marine gear oil level.

0000072enKMH60AOM

CAUTION

- During normal operation, the marine gear should only be shifted with the engine at idle.
- Shifting at higher engine speed will damage the marine gear.

0000073en

CAUTION

If the marine gear oil temperature is too high, stop engine immediately and check the marine gear oil level and check the oil cooler for proper coolant and water flow.

Have the marine gear serviced by an authorized Tuff Torq marine dealer or distributor before you start the engine again.

0000074enTT

CAUTION

After you add marine gear oil, run the engine for several minutes and shut it down. Wait at least 10 minutes to check the marine gear oil level. This allows the oil to drain back into the sump, otherwise, you may overfill the marine gear with oil.

0000075enKMH60AOM

CAUTION

New Marine Gear Break-In:

- On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper marine gear function and marine gear oil leaks.
- During the break-in period, carefully observe marine gear indicators (if any) for proper marine gear function.
- During the break-in period, check the marine gear oil levels frequently.

0000011enTrans

CAUTION

NEVER engage the starter motor while the engine is running. This may damage the starter motor pinion and / or ring gear.

0000012en

CAUTION

Protect the electric components from damage when you use steam or use high-pressure water to clean the engine or marine gear.

0000014enTrans

CAUTION

- **NEVER** attempt to modify the marine gear's design or safety features.
- Failure to comply may impair the marine gear's safety and performance characteristics and shorten the marine gear's life. Any alterations to this marine gear may affect the warranty coverage of your marine gear.

0000044enKMH60AOM

CAUTION

ALWAYS stop the engine immediately if any indicator illuminates during engine operation. Determine the cause and repair the problem before you continue to operate the engine.

0000029en

CAUTION

- **ALWAYS** be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- **NEVER** dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

0000013en

CAUTION

Establish a periodic maintenance plan according to the engine application and make sure you perform the required periodic maintenance at intervals indicated. Failure to follow these guidelines will impair the marine gear's safety and performance characteristics, shorten the marine gear's life and may affect the warranty coverage on your marine gear.

0000024enKMH60AOM

CAUTION

If you have more than one engine, you cannot shift the marine gear into the "B" position after you install the "emergency nut."

0000077en

CAUTION

It is important to perform daily checks.

Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor machine performance and helps extend the life of the marine gear.

0000060enTrans

CAUTION

Only use replacement parts specified. Other replacement parts may affect warranty coverage, cause internal marine gear components to seize, or shorten marine gear life.

0000147en

CAUTION

Always tighten to the specified torque. Loose parts can cause equipment damage or cause it to operate improperly.

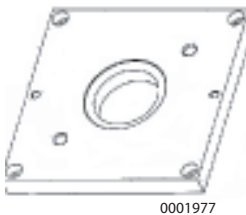
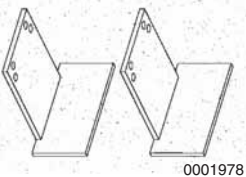


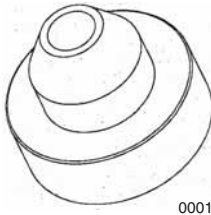
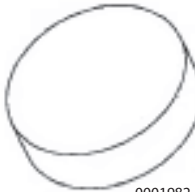
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PAST INSPECTIONS FOR THE ENGINE AND THE MARINE GEAR


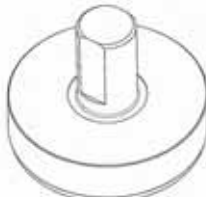

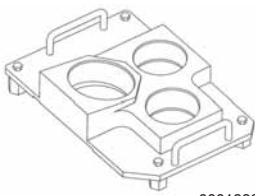
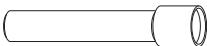
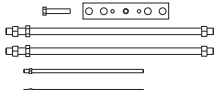
For precise, high-quality operation, preparation is necessary. Check the customer management file for the past performance of the engine and marine gear.


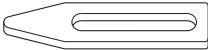
- When was the last maintenance done?
- How much has the marine gear been used (length of time / hours of use) since the last maintenance work?
- What problems were found at the last inspection, and what maintenance work was performed?
- Are the parts needed for replacement during maintenance on hand?
- Is there a check sheet for the maintenance work?

SPECIAL SERVICE TOOLS

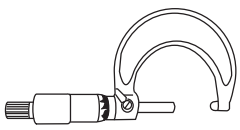
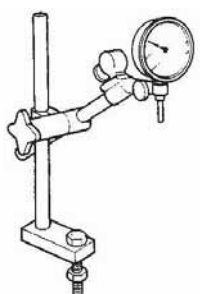
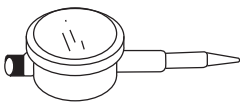
No	Tool Name	Applicable model and tool size	Illustration
1	Base (For Disassembly of Shaft Assembly)	Part No. 177524-09210	
2	Repair Stand	Part No. 177524-09110	
3	Spacer A	Part No. 177524-09320	
4	Spring Pusher	Part No. 177524-09310	
5	Shaft Stand	Part No. 177524-09240	
6	Spacer B	Part No. 177524-09240	

No	Tool Name	Applicable model and tool size	Illustration
7	Bearing Extractor (For Bearing and Collar on Engine Side)	Part No. 177524-09350	 0001983
8	Thrust Collar Extractor (For Collar on Propeller Side)	Part No. 177524-09380	 0001984
9	Wrench (For Output Coupling)	Part No. 177524-09160	 0001986
10	Master-Case A (Input Shaft) (For Shim Adjustment of Input Shaft and Support Shaft)	Part No. 177524-09510	 0001987
11	Master-Case A (Output Shaft) (For Shim Adjustment of Output Shaft Assembly)	Part No. 177524-09520	 0001988






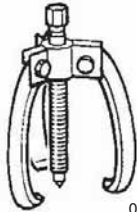

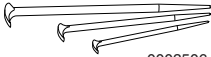
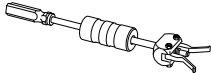
No	Tool Name	Applicable model and tool size	Illustration
12	Master-Case B (Input Shaft) (For Shim Adjustment of Input Shaft Assembly)	Part No. 177524-09540	 0001989
13	Master-Case B (Output Shaft) (For Shim Adjustment of Output Shaft Assembly)	Part No. 177524-09550	 0001990
14	Master-Case A (For Shim Adjustment of Case A)	Part No. 177524-09610	 0001991
15	Master-Case B (For Shim Adjustment of Case B)	Part No. 177524-09620	 0001992
16	Spring Press Tool (For Assembly of Shaft Assembly)	Part No. 177524-09010	 0003502
17	Arm Kit (For Disassembly of Shaft Assembly)	Part No. 177524-09200	 0003503

No	Tool Name	Applicable model and tool size	Illustration
18	Protector (For Disassembly of Bearing Cup)	Part No. 177524-09710	 0003504
19	Gear Steady (For Measuring of Backlash)	Part No. 177524-09730	 0003505

MEASURING INSTRUMENTS

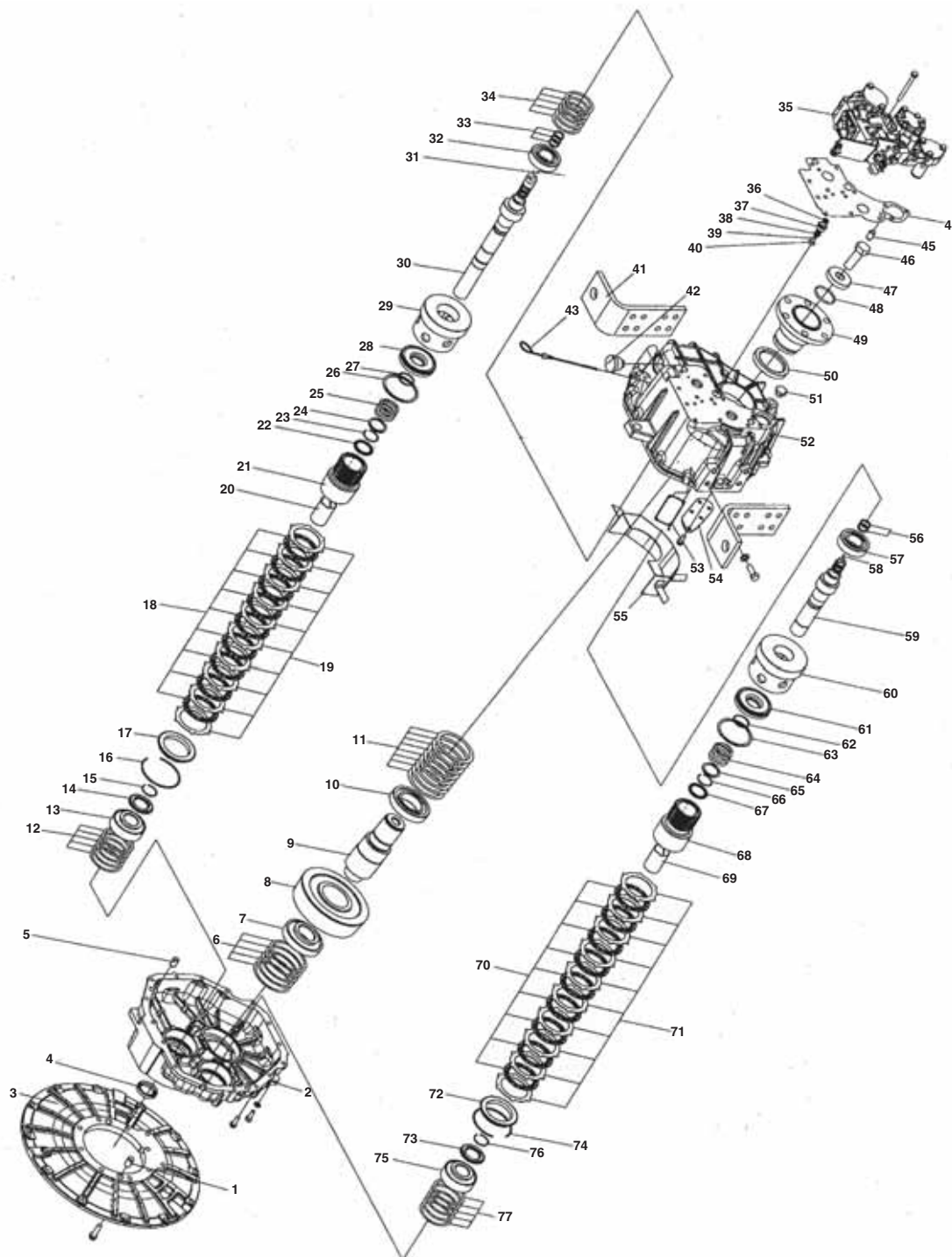
No.	Instrument Name	Application	Illustration
1	Micrometer	Measuring gauge from 0-25 mm. Accuracy of reading 1/100 mm	 0000834
2	Dial Indicator Gauge	Dial indicator gauge with arm-type support	 0001993
3	Dial Gauge		 0000831

STANDARD TOOLS

No.	Tool Name	Application	Illustration
1	Wrench	For hexagon bolts (8 mm, 12 mm, 14 mm, 17 mm, 24 mm)	 0001994
2	Allen Wrench	(6 mm, 8 mm)	 0001995
3	Hexagon Socket Wrench	(12 mm, 13 mm, 17 mm, 24 mm, 30 mm)	 0001996
4	Torque Wrench	Adjustable up to 450 N·m	 0001997
5	Plastic Hammer (1000 g) and Sturdy Screwdriver		 0001998
6	Extractor	Minimum diameter of 130 mm	 0001999
7	Hexagon Bit Sockets	(6 mm, 8 mm)	 0002910
8	Rolling Head Pry Bars		 0003506
9	Slide Hammer Bearing Puller		 0003507

TORQUE CHART

Item	Size	Torques	
Transmission Assembly Bolts	M8	18.6 - 22.6 N·m	13.7 - 16.7 ft-lb
	M10	37.2 - 41.2 N·m	27.5 - 30.4 ft-lb
	M12	65.7 - 75.5 N·m	48.5 - 55.7 ft-lb
Output Coupling Bolt	M20	401 - 441 N·m	296 - 326 ft-lb
Dipstick		Hand Tight	
Breather		Hand Tight	

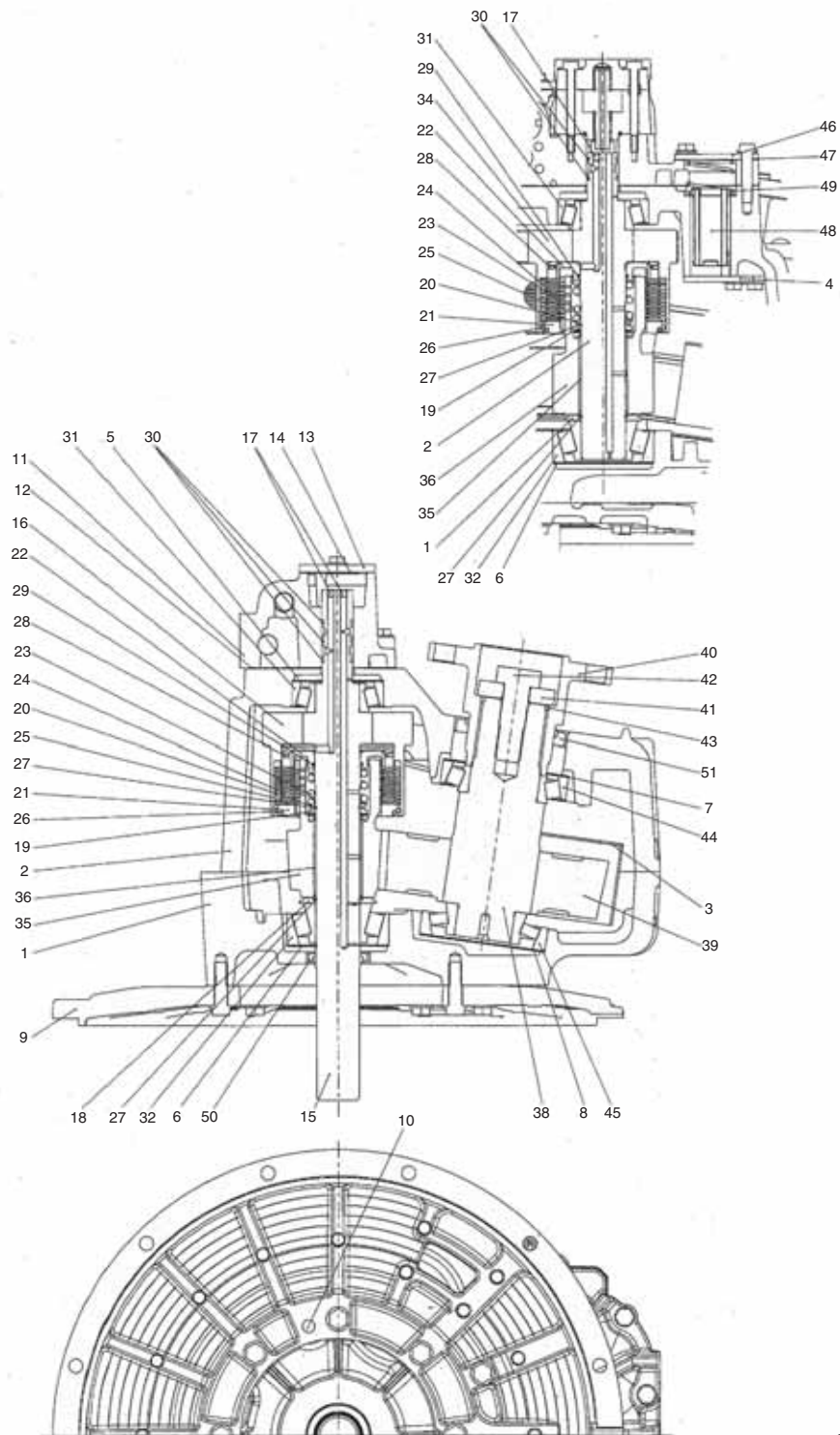
MARINE GEAR COMPONENT IDENTIFICATION

0001970

Figure 4-1

- | | |
|--|--|
| 1 – Parallel Pin | 52 – Case B |
| 2 – Case A | 53 – Name Plate |
| 3 – Mounting Flange | 54 – Cover Suction |
| 4 – Oil Seal | 55 – Baffle Plate |
| 5 – Parallel Pin | 56 – Seal Ring |
| 6 – Shims (0.1, 0.3, 0.5, and 1.0 mm) | 57 – Bearing |
| 7 – Bearing | 58 – Ball |
| 8 – Output Gear | 59 – Support Shaft |
| 9 – Output Shaft | 60 – Driven Gear |
| 10 – Bearing | 61 – Hydraulic Cylinder |
| 11 – Shims (0.1, 0.3, 0.5, and 1.0 mm) | 62 – Seal Ring |
| 12 – Shims (0.1, 0.3, 0.5, and 1.0 mm) | 63 – Seal Ring |
| 13 – Bearing | 64 – Spring |
| 14 – Thrust Collar | 65 – Spring Retainer |
| 15 – Ring | 66 – Ring |
| 16 – Ring | 67 – Thrust Collar |
| 17 – Friction Disc Retainer | 68 – Support Pinion |
| 18 – Friction Disc | 69 – Bushing |
| 19 – Steel Plate | 70 – Friction Disc |
| 20 – Bushing | 71 – Steel Plate |
| 21 – Input Pinion | 72 – Friction Disc Retainer |
| 22 – Thrust Collar | 73 – Thrust Collar |
| 23 – Ring | 74 – Ring (outer retaining) |
| 24 – Spring Retainer | 75 – Bearing |
| 25 – Return Spring | 76 – Ring (inner retaining) |
| 26 – Ring | 77 – Shims (0.1, 0.3, 0.5, and 1.0 mm) |
| 27 – Ring | |
| 28 – Hydraulic Cylinder | |
| 29 – Drive Gear | |
| 30 – Input Shaft | |
| 31 – Ball | |
| 32 – Bearing | |
| 33 – Seal Ring | |
| 34 – Shims (0.1, 0.3, 0.5, and 1.0 mm) | |
| 35 – Case Plate | |
| 36 – Spring Retainer | |
| 37 – 2nd Relief Seat | |
| 38 – Spring | |
| 39 – Spring Pin | |
| 40 – 2nd Relief Valve | |
| 41 – Mounting Foot | |
| 42 – Breather | |
| 43 – Dipstick | |
| 44 – Gasket | |
| 45 – Parallel Pin | |
| 46 – Bolt | |
| 47 – Coupling Plate | |
| 48 – O-ring | |
| 49 – Output Coupling | |
| 50 – Oil Seal | |
| 51 – Plug | |

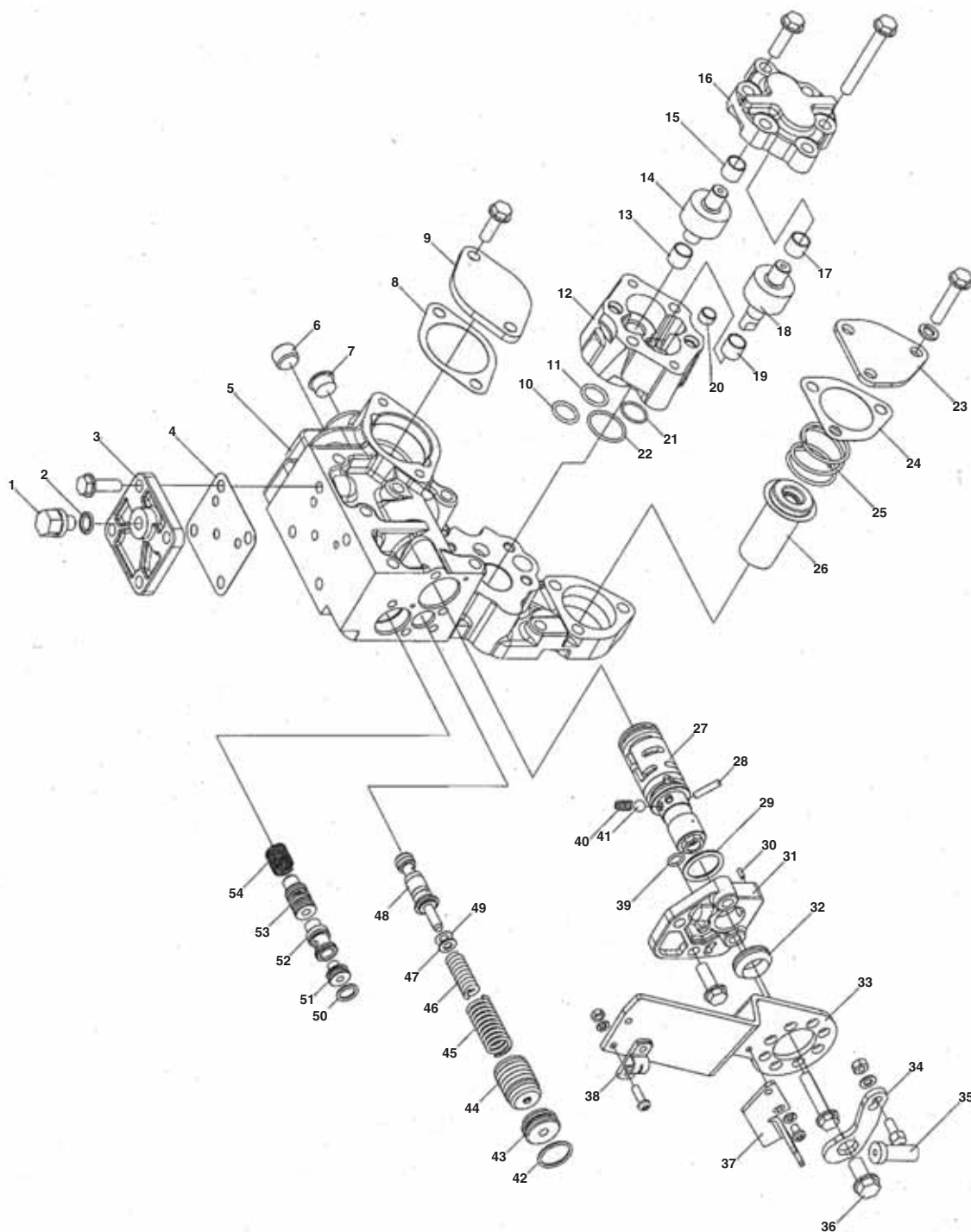
MARINE GEAR SECTIONAL VIEW



0001972

Figure 4-2

- 1 – Case A
- 2 – Case B
- 3 – Baffle Plate
- 4 – Suction Cover
- 5 – Shim
- 6 – Shim
- 7 – Shim
- 8 – Shim
- 9 – Mounting Flange
- 10 – Parallel Pin
- 11 – Case Plate
- 12 – Gasket
- 13 – PTO Cover
- 14 – Gasket
- 15 – Input Shaft
- 16 – Drive Gear
- 17 – Ball
- 18 – Thrust Collar Eng.
- 19 – Thrust Collar Prop.
- 20 – Spring Retainer
- 21 – Friction Disc Retainer
- 22 – Hydraulic Cylinder
- 23 – Return Spring
- 24 – Friction Disc
- 25 – Steel Plate
- 26 – Ring
- 27 – Ring
- 28 – Ring
- 29 – Ring
- 30 – Ring
- 31 – Bearing
- 32 – Bearing
- 33 – Support Shaft
- 34 – Driven Gear
- 35 – Input Pinion
- 36 – Bushing
- 37 – Support Pinion
- 38 – Output Shaft
- 39 – Output Gear
- 40 – Output Coupling
- 41 – Coupling Plate
- 42 – Bolt
- 43 – O-ring
- 44 – Bearing
- 45 – Bearing
- 46 – Strainer Cover
- 47 – Gasket
- 48 – Filter
- 49 – Strainer Spring
- 50 – Oil Seal

CASE PLATE COMPONENT IDENTIFICATION

0001971

Figure 4-3


- | | |
|-----------------------|---------------------|
| 1 – Plug | 52 – Pilot Valve |
| 2 – O-ring | 53 – Throttle Valve |
| 3 – Upper Cover | 54 – Spring |
| 4 – Gasket | |
| 5 – Case Plate | |
| 6 – Plug | |
| 7 – Cap | |
| 8 – Gasket | |
| 9 – PTO Cover | |
| 10 – O-ring | |
| 11 – O-ring | |
| 12 – Pump Body | |
| 13 – Bearing | |
| 14 – Pump Driven Gear | |
| 15 – Bearing | |
| 16 – Pump Cover | |
| 17 – Bearing | |
| 18 – Pump Drive Gear | |
| 19 – Bearing | |
| 20 – Pin | |
| 21 – O-ring | |
| 22 – O-ring | |
| 23 – Strainer Cover | |
| 24 – Gasket | |
| 25 – Strainer Spring | |
| 26 – Filter | |
| 27 – Shifting Valve | |
| 28 – Pin | |
| 29 – O-ring | |
| 30 – Pin | |
| 31 – Cover | |
| 32 – V-ring | |
| 33 – Wire Bracket | |
| 34 – Shifting Lever | |
| 35 – Ball Joint | |
| 36 – Bolt | |
| 37 – Switch Support | |
| 38 – Clamp | |
| 39 – O-ring | |
| 40 – Spring | |
| 41 – Ball | |
| 42 – O-ring | |
| 43 – Cover | |
| 44 – Modulating Valve | |
| 45 – Spring | |
| 46 – Spring | |
| 47 – Shim | |
| 48 – HO Relief Valve | |
| 49 – Shim | |
| 50 – O-ring | |
| 51 – Cover | |

PREPARING FOR OVERHAUL

Prepare for the disassembly of the marine gear as follows.

1. Secure the marine gear on a level base.

⚠ DANGER




CRUSH HAZARD!

- Always use lifting equipment with sufficient capacity to lift marine gear.
- Have a helper assist you attaching the marine gear to the hoist.
- NEVER** stand under hoisted marine gear. If the hoist mechanism fails, the marine gear will fall on you, causing serious injury or death.
- NEVER** support marine gear with equipment not designed to support the weight of the marine gear such as wooden pieces, blocks or by only using a jack.
- Failure to comply will result in death or serious injury.**

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⚠ CAUTION



FLYING OBJECT HAZARD!

- ALWAYS** wear eye protection when servicing marine gear and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.
- Failure to comply may result in minor or moderate injury.**

0000003enTrans

Notes:

- Be sure to replace the parts which upon inspection and measurement are faulty, whose measurements are outside the prescribed limits, or have exceeded the prescribed period of use.
- Parts which still meet the standard measurements and prescribed period of use, but which are expected to fall below the standard before the next inspection should also be replaced.

2. Clean off any dirt, oil or dust on the marine gear with detergent, air or steam.

Note: Be careful not to get any dust inside the marine gear during operation.

DISASSEMBLY OF MARINE GEAR

If necessary, make alignment marks on parts to make reassembly easier.

As each part is removed, check its condition and appearance for changes in shape, damage and scratches.

Disassemble the parts in an orderly manner separating parts which can be used from those which need to be replaced.

Draining Transmission Oil

WARNING



BURN HAZARD!

- If you must drain the marine gear oil while it is still hot, stay clear of the hot marine gear oil to avoid being burned.
- **ALWAYS** wear eye protection.
- Failure to comply could result in death or serious injury.

0000011enTrans

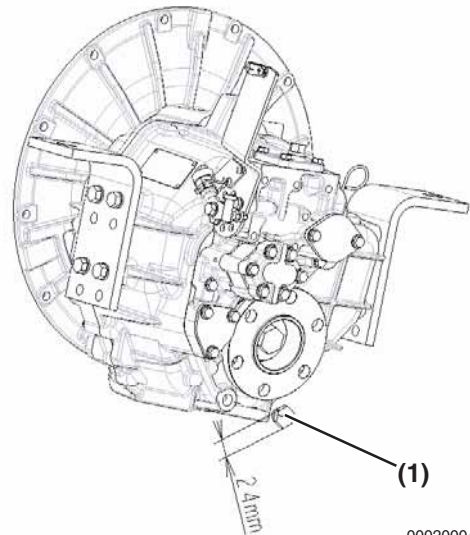
CAUTION



- **ALWAYS** be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- **NEVER** dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

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1. Position a container under the marine gear to collect the waste oil.
2. Remove the drain plug (**Figure 4-4, (1)**) with seal using a 24 mm socket wrench.
3. Check the drain seal for damage. Replace if necessary.



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Figure 4-4

Removal of Oil Filter

1. Remove the three M8x40 bolts (**Figure 4-5, (2)**) of lock washers with 12 mm socket wrench.
2. Remove the filter cover (**Figure 4-5, (3)**), gasket, strainer spring (**Figure 4-5, (4)**) and oil filter (**Figure 4-5, (1)**).
3. Check the gasket for damage. Replace if necessary.

Note: The oil filter (**Figure 4-5, (1)**) must be washed with clean oil whenever the oil is changed.

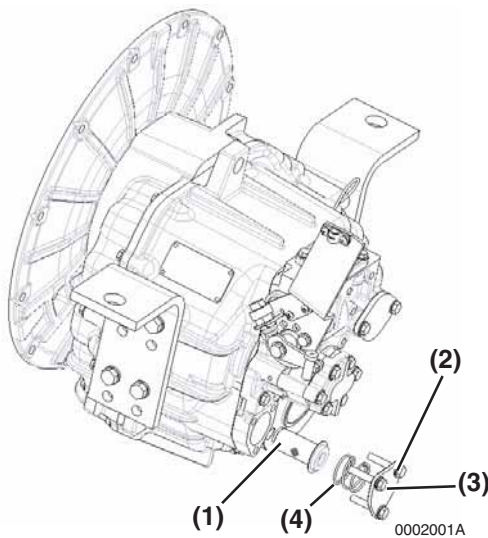


Figure 4-5

Removal of Dipstick

1. Remove dipstick (**Figure 4-6, (1)**).

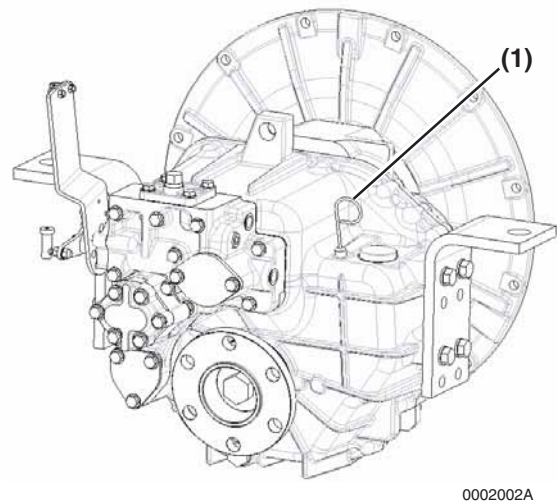


Figure 4-6

Removal of Output Coupling

1. Lock output coupling in swivel frame with flange stabilizing wrench (**Figure 4-7, (2)**).
2. Remove M20x60 hex head bolt (**Figure 4-7, (1)**) with 30 mm socket wrench.
3. Remove coupling plate (**Figure 4-8, (1)**) and O-ring (**Figure 4-8, (2)**).
4. Using a gear puller, remove output coupling (**Figure 4-9, (1)**).

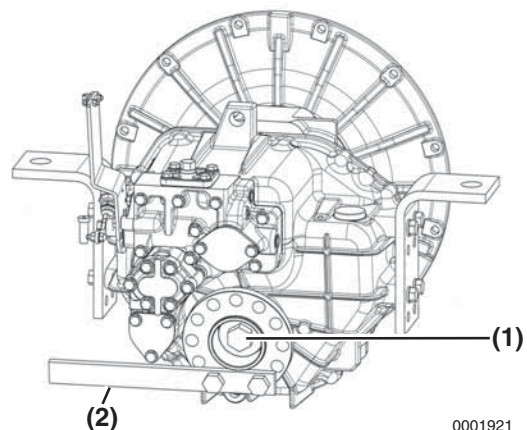


Figure 4-7

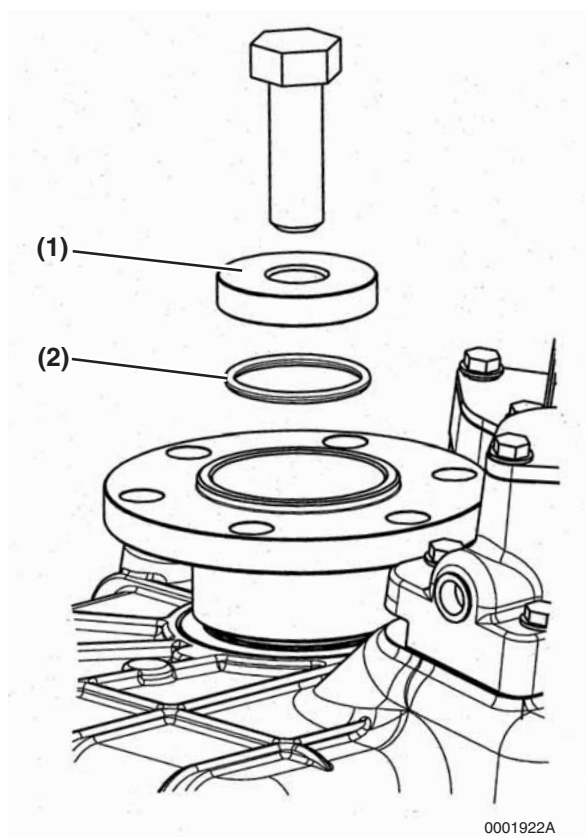


Figure 4-8

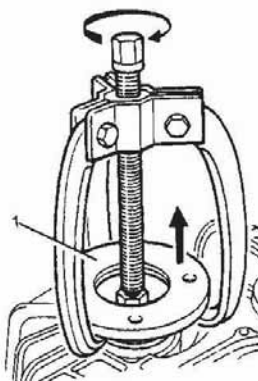


Figure 4-9

Removal of Hydraulic Oil Pump

1. Remove four M8x65 hex head bolts (Figure 4-10, (1)).
2. Remove oil pump (Figure 4-10, (2)).

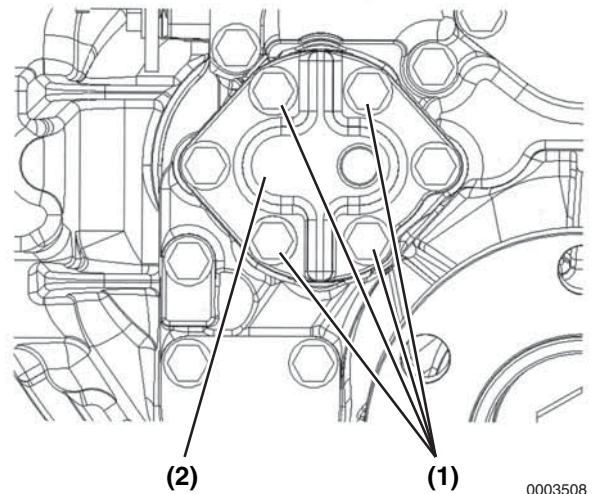
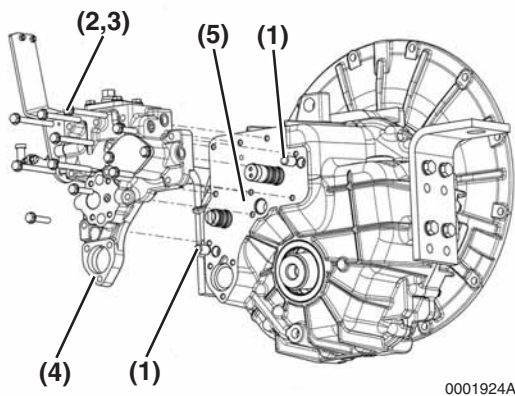
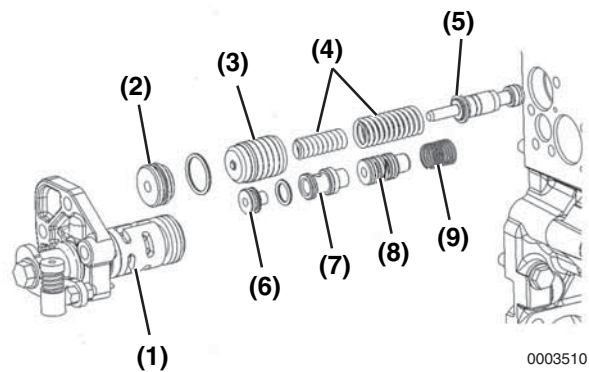


Figure 4-10

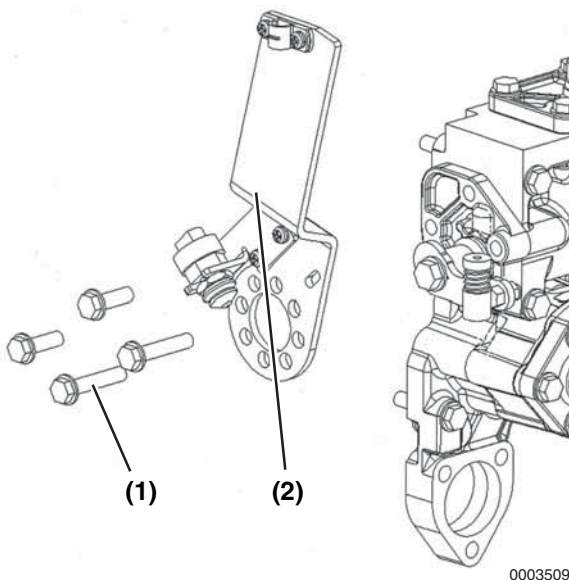
Removal of Case Plate

1. Loosen and remove all 10 M8 hex head bolts and lock washers (Figure 4-11, (2 & 3)) with 12 mm socket wrench.
2. Using a plastic hammer, lightly tap the split line of the case plate surface to break the seal.
3. Remove case plate (Figure 4-11, (4)) and lubricating pressure relief valve (Figure 4-11, (5)).
4. Remove parallel pins (Figure 4-11, (1)).

**Figure 4-11****Figure 4-13**

Removal of Valves

1. Loosen and remove four hex bolts (**Figure 4-12, (1)**).
2. Remove wire bracket (**Figure 4-12, (2)**).

**Figure 4-12**

3. Remove shifting valve (**Figure 4-13, (1)**).

4. Remove cover for HO relief valve with O-ring (**Figure 4-13, (2)**).
5. Remove modulating valve (**Figure 4-13, (3)**).
6. Remove springs (**Figure 4-13, (4)**).
7. Remove HO relief valve with shims (**Figure 4-13, (5)**).
8. Remove cover for reducing valve with O-ring (**Figure 4-13, (6)**).
9. Remove pilot valve (**Figure 4-13, (7)**).
10. Remove throttle valve (**Figure 4-13, (8)**).
11. Remove spring (**Figure 4-13, (9)**).

Removal of Mounting Feet

1. Remove two mounting feet (**Figure 4-14, (1)**).
2. Install repair stand (**Figure 4-14, (2)**) to housing.

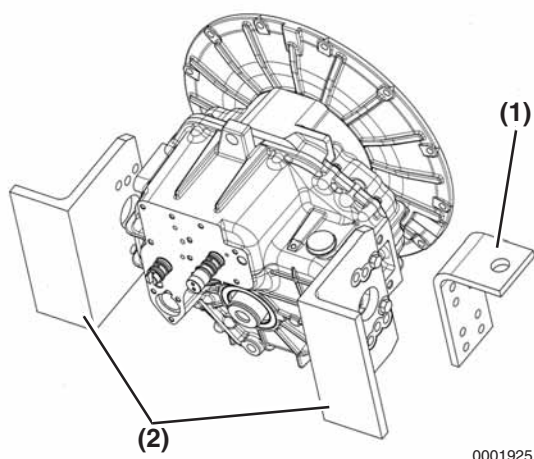


Figure 4-14

Removal of Mounting Flange

1. Remove ten M10x35 hex head bolts (**Figure 4-15, (1)**) with 14 mm socket wrench.
2. Remove two locating pins (**Figure 4-15, (2)**).

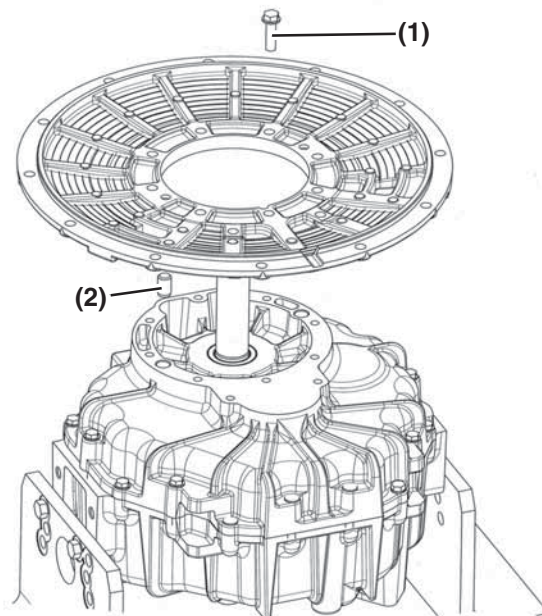


Figure 4-15

Disassembly of Cases

1. Loosen and remove all (15) M8 hex bolts and lock washers (**Figure 4-16, (2 and 3)**) using both 12 mm and 13 mm socket wrenches. Note the location of two recessed bolts near input shaft and four stainless steel bolts at lower side of housing (**Figure 4-17, (1)**).
2. Lightly tap case A (**Figure 4-16, (4)**) with plastic hammer. Prying with sharp tools can result in damage to sealing surface, leakage of oil, and failure of gear.
3. Remove parallel pins (**Figure 4-16, (1)**).

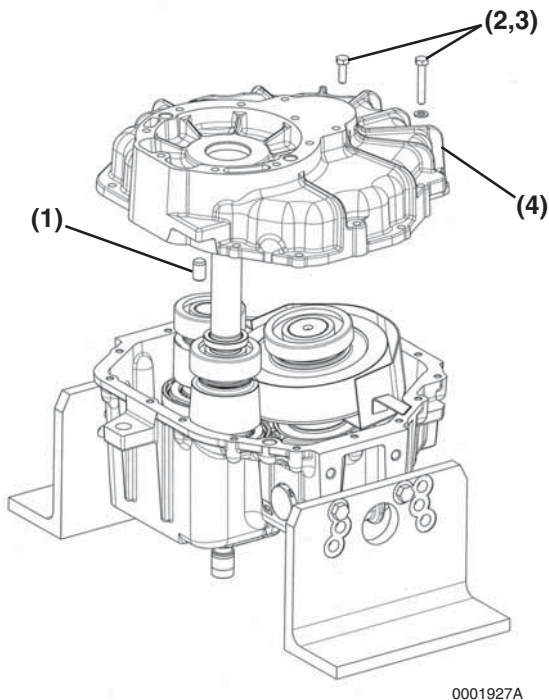


Figure 4-16

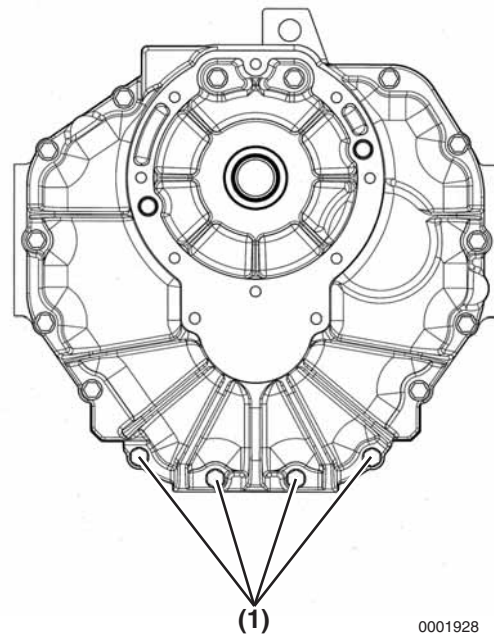


Figure 4-17

Removal of Shafts and Gears

1. Remove gear set from case B:
 - Input shaft (**Figure 4-18, (1)**) assembly
 - Support shaft (**Figure 4-18, (2)**) assembly
 - Output shaft (**Figure 4-18, (3)**) assembly

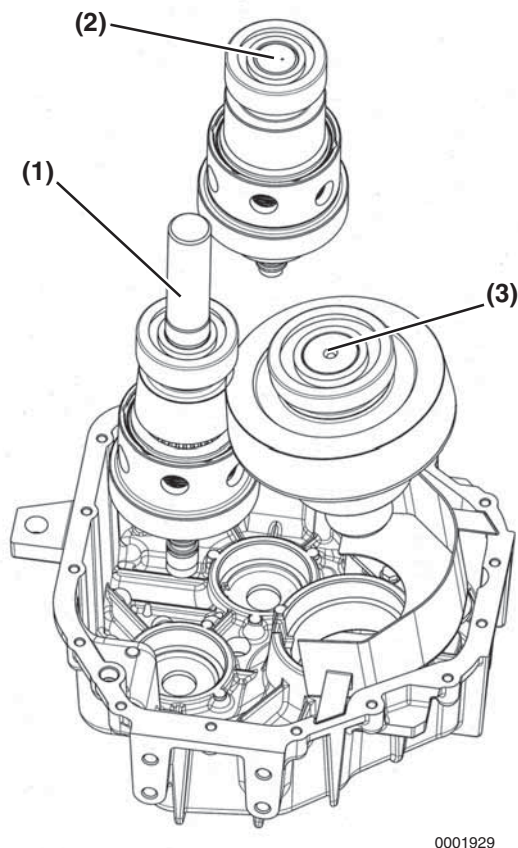


Figure 4-18

2. If it is needed (when adjustment of shim is needed) remove bearing races by using Rolling Head Pry Bars or Slide Hammer Bearing Puller.
3. If you use a Rolling Head Pry Bars for removal of case A input bearing races, you should use protector (**Figure 4-19, (1)**) and (**Figure 4-20**).

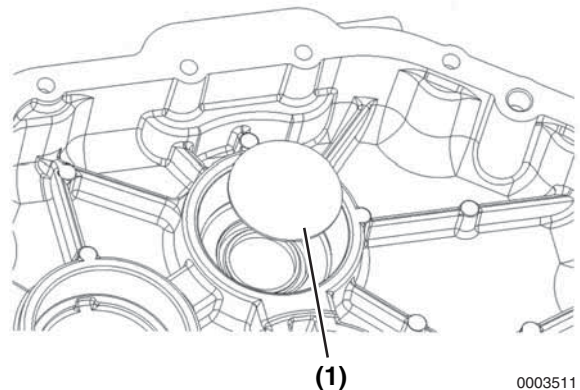


Figure 4-19

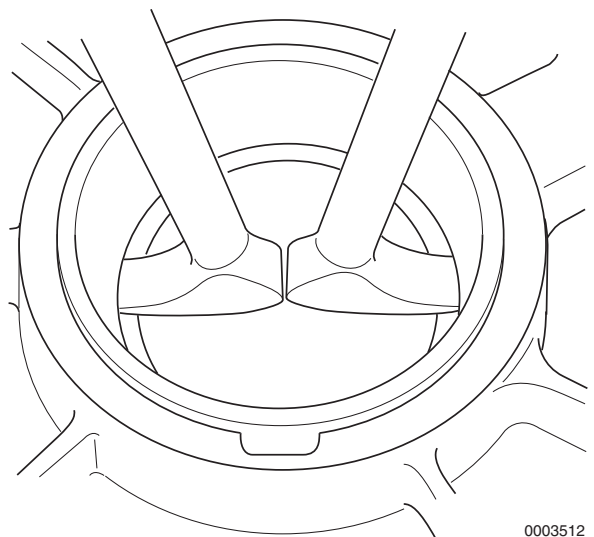


Figure 4-20

4. Remove the shims from case A and case B on the input shaft.
5. Remove the shims from case A and case B on the output shaft.
6. Remove the shims from case A on the support shaft.

Removal of Tapered Roller Bearings Outer Races

WARNING

Use heat resistant gloves when handling the hot housing halves and outer races.

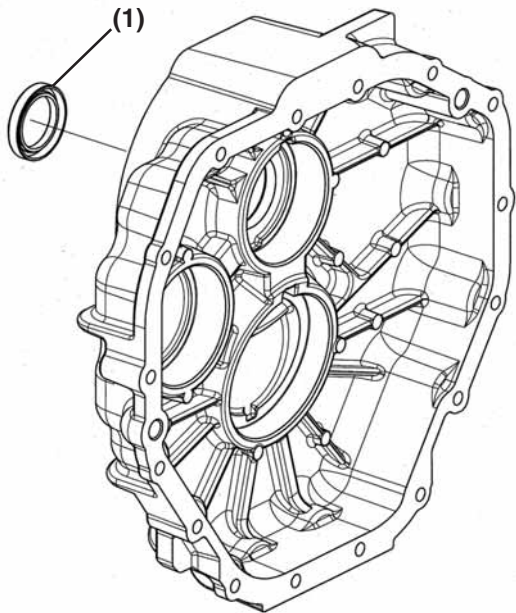
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Remove the tapered roller bearings' outer races from the cases by heating the cases in an oven to approximately 120°C (250°F): Put the housing in the oven upside down, so the outer races will fall out.

- The case can be heated by using other methods such as a torch or heat gun.
- Be sure to keep the shims together with the same outer races from where they were removed. Properly identify shims and outer races.

Removal of Oil Seals

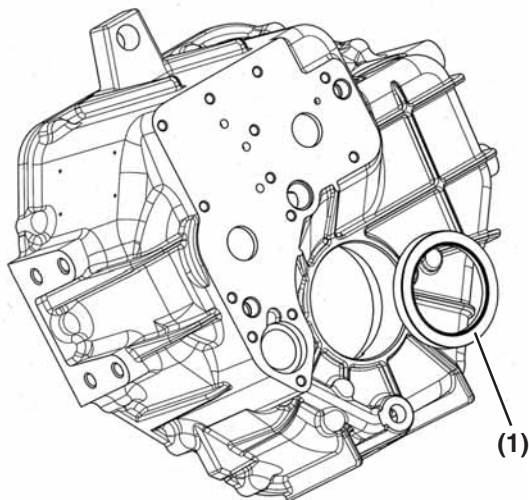
1. Remove and discard input oil seal (**Figure 4-21, (1)**).



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Figure 4-21

2. Remove and discard output oil seal (**Figure 4-22, (1)**).



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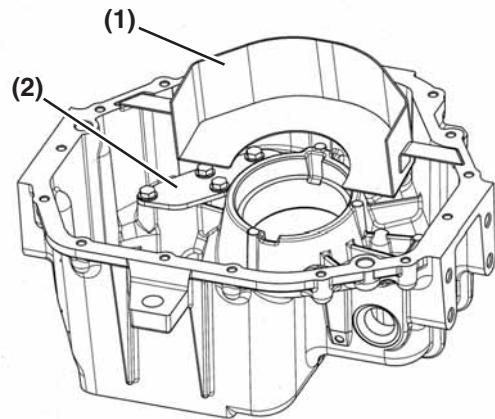
Figure 4-22

Removal of Baffle Plate and Oil Suction Cover

1. Remove baffle plate (**Figure 4-23, (1)**) and oil suction cover (**Figure 4-23, (2)**) from case B.

Note: The oil suction cover removal is optional.

2. Protect the housing. Be sure to keep any dirt out of housing.



0001932

Figure 4-23

Removal of Seal Rings

1. Remove seal rings (**Figure 4-24, (1)**) from input shaft and support shaft.

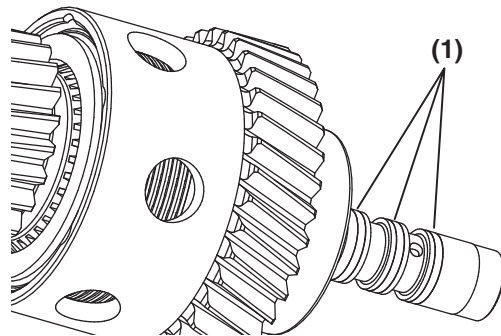


Figure 4-24

Removal of Tapered Roller Bearings

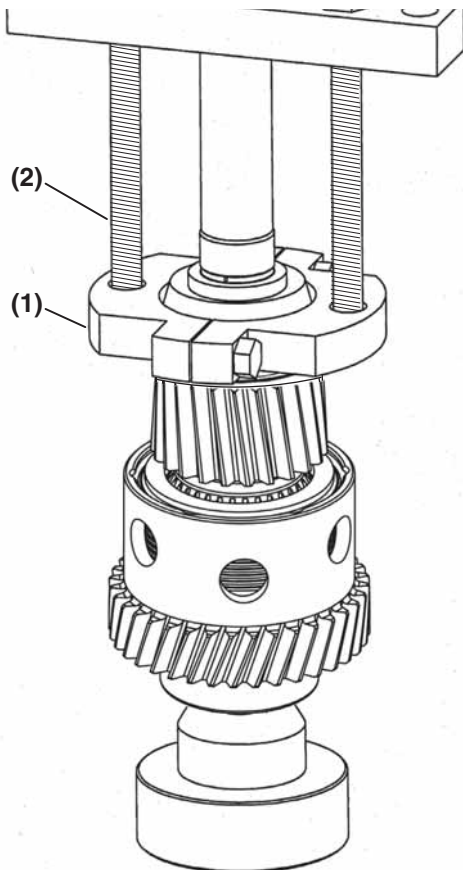
Check for failed bearings or excessive bearing wear. If bearings are damaged, replace both the outer bearing race and inner bearing race.

Removal of Taper Roller Bearings' Inner Races

Input Shaft and Support Shaft - Engine Side

Remove the engine side tapered roller bearing inner races with thrust collar by using a bearing extractor (**Figure 4-25, (1)**) along with the arm and threaded rod M16 × 600 (**Figure 4-25, (2)**).

- Be sure to pull on the thrust collar not on the bearing.
- Note the direction that the thrust collar is installed on shaft.



0001933

Figure 4-25

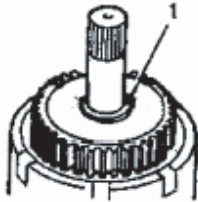
Input Shaft and Support Shaft - Propeller Side

Do not disassemble the shaft and piston housing. If a bearing is damaged, replace the complete bearing set.

Removal of Clutch pack

Removal of Clutch Discs

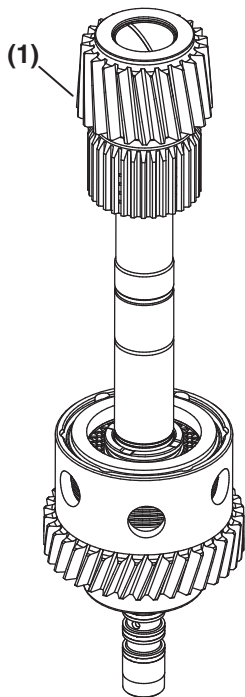
1. To remove clutch discs from input shaft, remove retaining ring (**Figure 4-26, (1)**).



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Figure 4-26

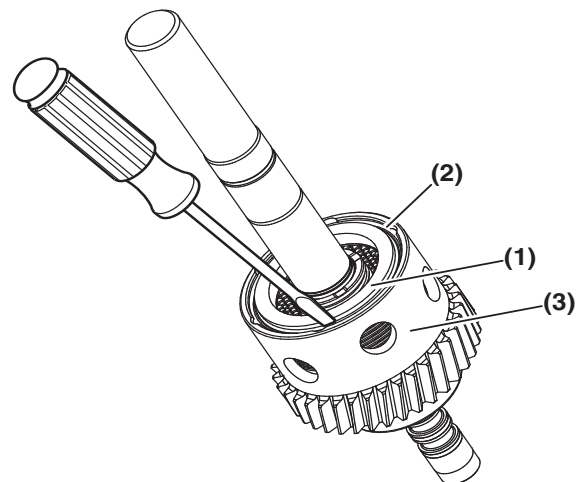
2. Slide pinion gear assembly (**Figure 4-27, (1)**) off input shaft.



0001934

Figure 4-27

3. Carefully remove outer retaining ring (**Figure 4-28, (1)**).
4. Remove friction disc retainer (**Figure 4-28, (2)**).
5. Remove steel plates and friction discs from the case.
6. Repeat same procedure to remove the friction disc retainer from the support shaft.



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Figure 4-28

Removal of Clutch Pistons

1. To remove clutch pistons from input shaft, remove thrust collar (**Figure 4-29, (1)**) by using an extractor (**Figure 4-29, (2)**).

Note: Make sure to observe the direction the thrust collar is mounted to the shaft.

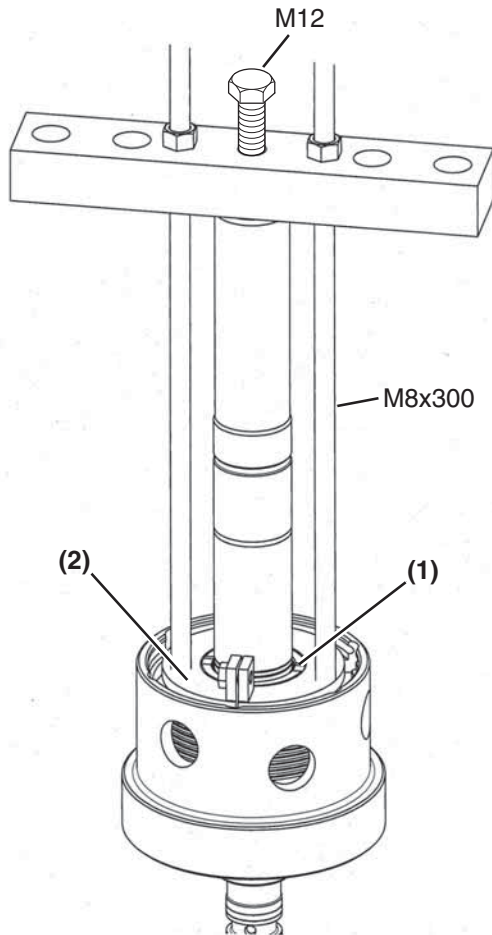


Figure 4-29

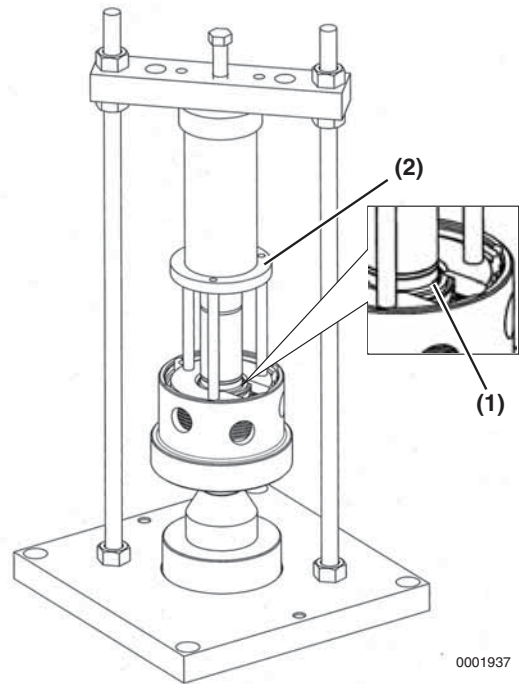


Figure 4-30

2. Using a spring compressor (**Figure 4-30, (2)**), compress the spring no more than 5 mm.
3. Remove snap ring (**Figure 4-30, (1)**).
4. Remove inner retaining ring (**Figure 4-31, (1)**) from groove.

5. Remove the spring retainer, return spring (**Figure 4-31, (2)**) and hydraulic cylinder (**Figure 4-31, (3)**). This may require application of low pressure air to opening in end of shaft to remove piston.

Note: Make sure to observe the direction the retaining ring is installed on the shaft (chamber facing up).

6. Repeat same procedure for support shaft.

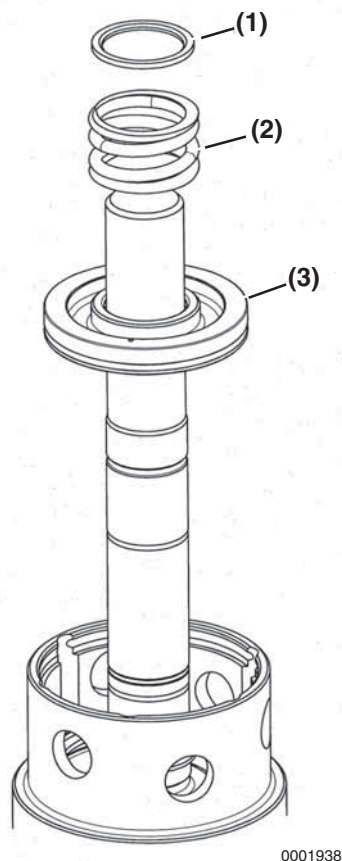


Figure 4-31

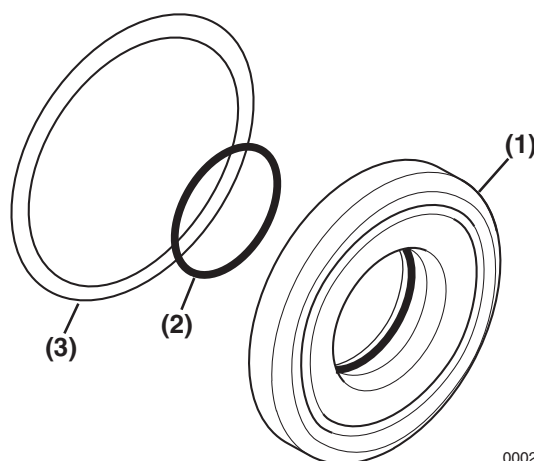


Figure 4-32

CLEANING OF MARINE GEAR

Note: Discard all gaskets, seals, O-rings, piston rings and seal rings. Replace any part that was damaged from disassembly.

⚠ WARNING



FUME / BURN HAZARD!

- **ALWAYS** read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.
- **Failure to comply could result in death or serious injury.**

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Use EPA / OSHA approved solvents. Parts must be dried and oiled immediately after cleaning. Be sure parts are free from grit, dirt and abrasives.

- Only use clean solvent to flush valves.
- Be sure to flush all hoses and the heat exchanger.

Do not remove packing grease from new bearings. Thoroughly wash used bearings. Do not use compressed air to dry the bearings.

Remove all old sealant from sealed joints. Thoroughly clean the surfaces to remove old sealant and grease.

INSPECTION OF MARINE GEAR

Cases

Replace any case that is cracked.

Inspect machined surfaces and bores for wear, grooves or scratches. Only use crocus cloth or a soft stone to remove scratches and burrs.

Repair any damaged threads using the correct size tap or thread repair kit.

Bearings

Replace any bearing that was removed by using a service tool.

Replace bearings that show signs of corrosion and wear such as scoring, scratching, cracked pitting or chipping.

Replace bearing if its rotation is rough.

Inspect bearing bores and shafts for grooves, burrs or galling. Replace the part if crocus cloth can not repair the damage.

Shafts and Gears

Check all gears, bearings, piston rings on the input shaft and support shaft for signs of wear or failure.

If any of the gears are damaged or showing signs of excessive wear, Tuff Torq recommends replacing the complete gear set.

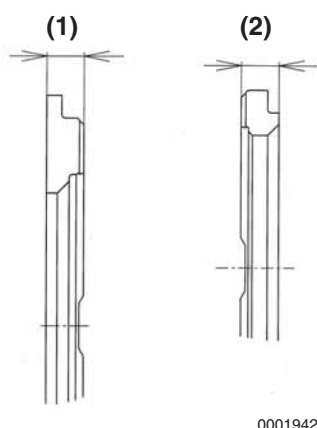
To check for correct clutch operation, rotate the gears on the input shaft.

Inspect clutch for excessive wear, replace clutch as required by feeling of smooth rotating only.

Friction Disc

Stepped Wear	Standard	Limit
Friction Disc	1.65 - 1.75 mm (0.065 - 0.069 in.)	1.55 mm (0.061 in.)

Thrust Collars



0001942

Figure 4-33

Stepped Wear	Standard	Limit
Engine Side	4.85 - 4.95 mm (0.191 - 0.195 in.)	4.65 mm (0.183 in.)
Propeller Side	4.90 - 5.00 mm (0.193 - 0.197 in.)	4.70 mm (0.185 in.)

REASSEMBLY OF MARINE GEAR

Be sure to use genuine parts for replacements including new gaskets, seals, O-rings, piston rings and seal rings.

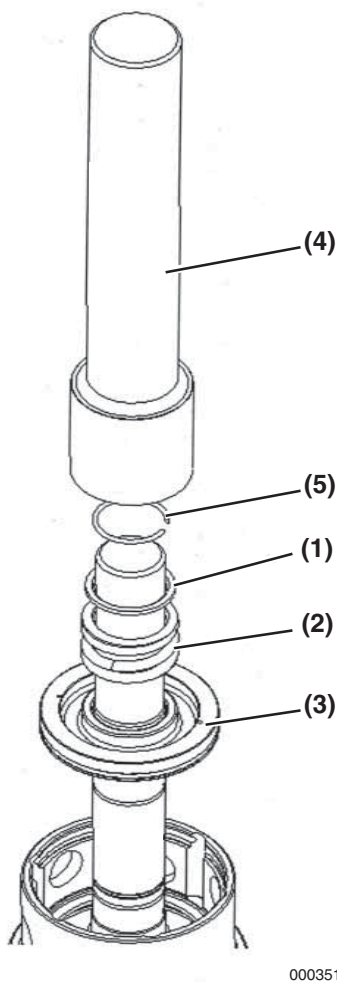
Use the correct parts and assemble them in the correct manner to specified standards (tightening torque, adjustment values, etc.). Also grease the important bolts and nuts as specified.

Depending upon the placement of the packing, grease the seal packing. Oil or grease moving parts. Grease lip of oil seals.

Reassembly of Input Shaft and Support Shaft

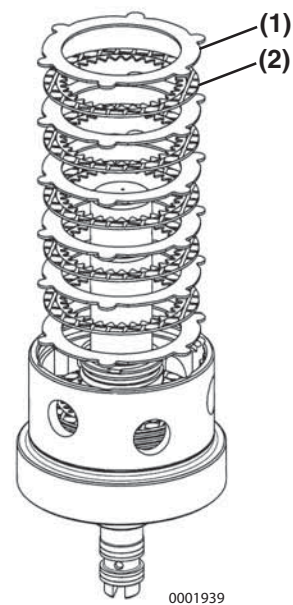
Reassembly of Friction Assembly

1. Lubricate and install two new seal rings on input shaft piston. Do not stretch seal rings when installing.
2. Install piston (**Figure 4-34, (3)**) into clutch housing, being careful not to damage seal rings. Install return spring (**Figure 4-34, (2)**), inner retaining ring (**Figure 4-34, (1)**) and snap ring (**Figure 4-34, (5)**) by applying pressure with return spring compression tool (**Figure 4-34, (4)**). Be sure inner retaining ring is locked into second groove on shaft with chamfered side facing up.

**Figure 4-34**

3. Install thrust collar.
4. Lubricate steel plates and friction discs. Install steel plates (**Figure 4-35, (1)**) and discs (**Figure 4-35, (2)**) beginning and ending with a steel plate.

Note: Refer to Parts Catalog for exact quantity of steel plates and friction discs.

**Figure 4-35**

5. Install friction disc retainer (**Figure 4-36, (1)**). Install and seat outer retaining ring (**Figure 4-36, (2)**) into groove on shaft with chamfer side of ring facing up. Check for friction disc retainer alignment and full engagement.

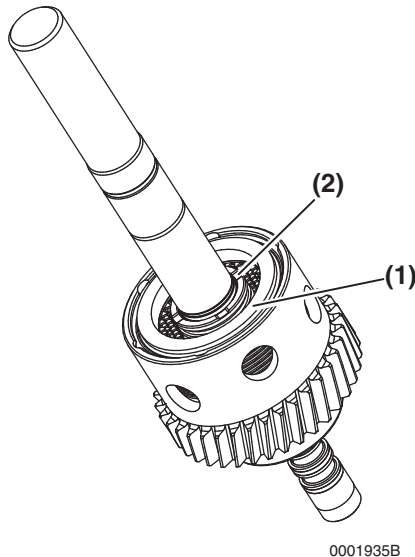


Figure 4-36

6. Repeat same procedure for support shaft.

Reassembly of Pinion Gear Assemblies

1. Lubricate and slide pinion gear assembly (**Figure 4-37, (1)**) onto the shaft.
2. Secure pinion gear assembly with retaining ring (**Figure 4-37, (2)**).

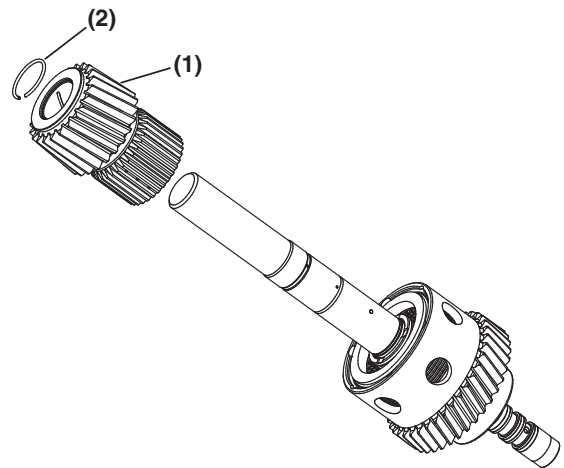




Figure 4-37

3. Repeat same procedure for support shaft.

Reassembly of Thrust Collars

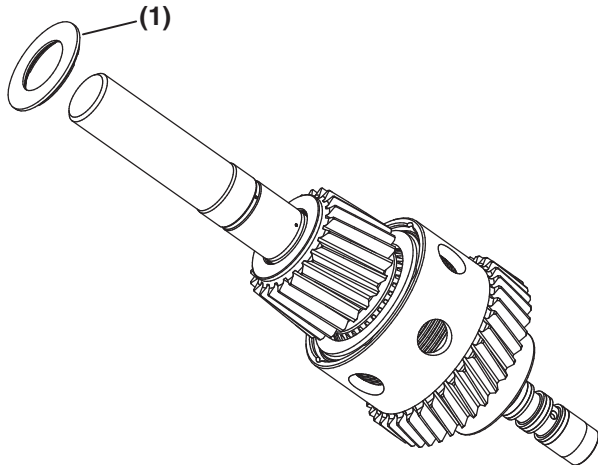
1. Heat thrust collars to 120°C (250°F).

 WARNING

<p>BURN HAZARD!</p> <ul style="list-style-type: none"> • Handle heated thrust collars with heat resistant gloves! • Failure to comply could result in death or serious injury.

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2. Press thrust collars (**Figure 4-38, (1)**) onto both the input and support shafts.
 - The engine side thrust collar must be installed with lining facing down.
 - The propeller side thrust collar must be installed with the lining facing up.

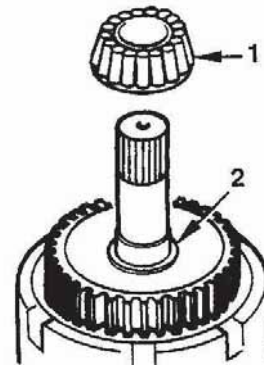
3. Make sure thrust collars are fully pressed on shaft and have a clearance of 0.25 - 1.05 mm (0.010 - 0.041 in.) between thrust collar and top of pinion gear assembly.
4. Verify that the thrust collars are not bent after installing.



0001941

Figure 4-38

2. Carefully press inner race (Figure 4-39, (1)) onto the shaft until inner race is against thrust collar (Figure 4-39, (2)). Be careful not to damage roller cage when installing the inner race.



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Figure 4-39

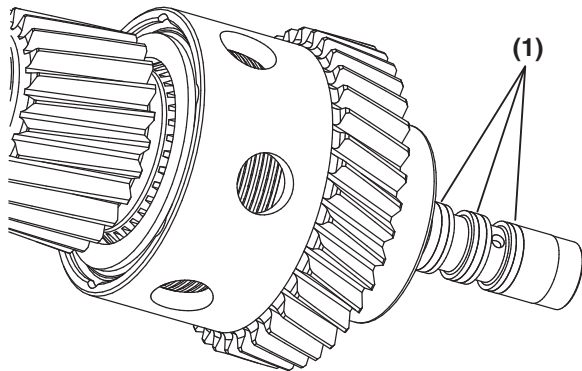
Reassembly of Tapered Roller Bearings Onto Input and Support Shafts

1. Heat inner race of tapered bearing to approximately 120°C (250°F).

⚠ WARNING
<p>BURN HAZARD!</p> <ul style="list-style-type: none"> • Handle heated tapered roller bearings with heat resistant gloves! • Failure to comply could result in death or serious injury.
<p>0000104en</p>

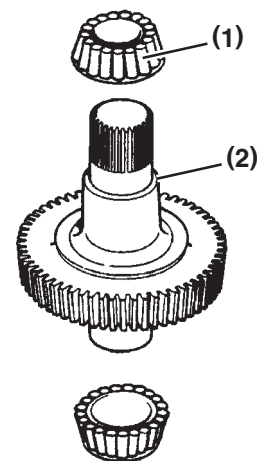
Reassembly of Seal Rings

1. Lubricate seal rings (**Figure 4-40, (1)**) with grease.
2. Install seal rings onto input shaft and support shaft.



0001943

Figure 4-40



0002006

Figure 4-41

Reassembly of Tapered Roller Bearing Onto Output Shaft

1. If previously removed, reinstall tapered roller bearing onto output shaft.
2. Heat inner race of tapered bearing to approximately 120°C (250°F).

⚠ WARNING
<p>BURN HAZARD!</p> <ul style="list-style-type: none"> • Handle heated tapered roller bearings with heat resistant gloves! • Failure to comply could result in death or serious injury.

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3. Carefully press inner race (**Figure 4-41, (1)**) onto the output shaft until inner race butts against the shoulder of shaft (**Figure 4-41, (2)**).

Adjustment of Gear Backlash

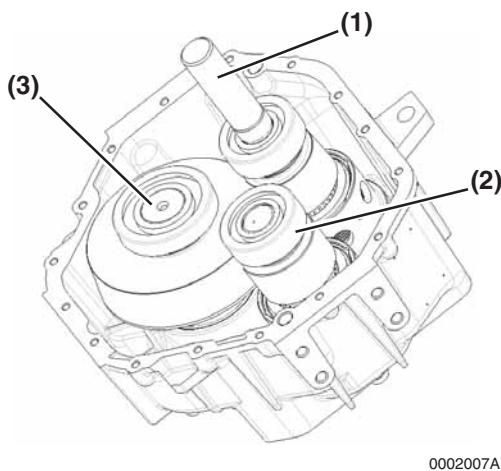
This procedure is required only when a gear ratio is changed.

Notes:

- The propeller side shim is for adjusting gear backlash.
- The engine side shim is for adjusting bearing side clearance.

Use the following procedure to adjust gear backlash.

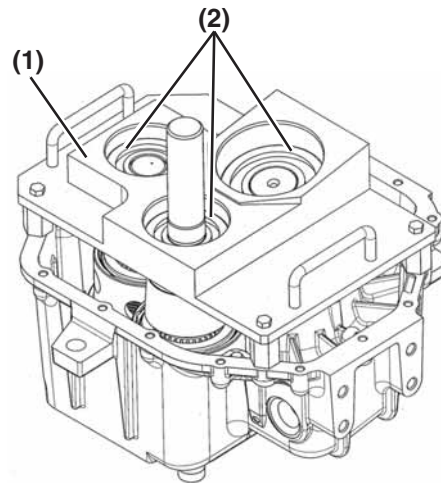
1. Install input shaft assembly in case B with a 0.9 mm shim behind outer race of bearing **(Figure 4-42, (1))**.



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Figure 4-42

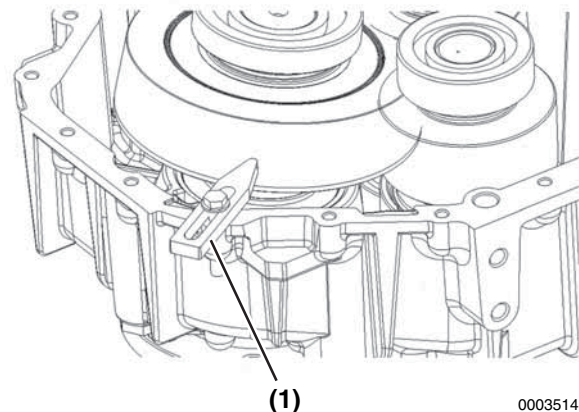
2. Install support shaft assembly in case B. A shim is not required **(Figure 4-42, (2))**.
3. Install output shaft assembly in case B with a 0.9 mm shim behind the outer race of bearing **(Figure 4-42, (3))**.
4. Set the special tool **(Figure 4-43, (1))**. Place outer race of each bearing onto each individual shaft **(Figure 4-43, (2))**.



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Figure 4-43

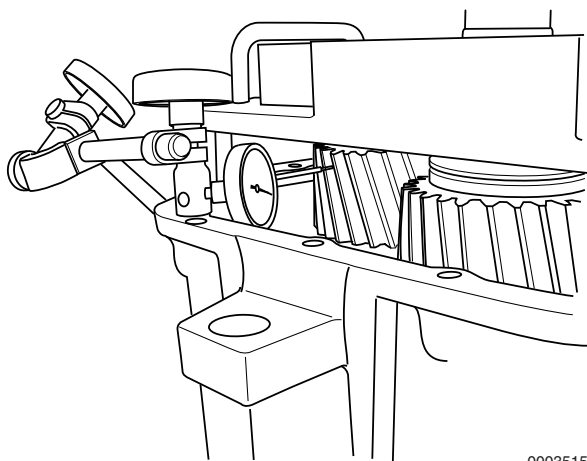
5. Fix the output gear by gear steady **(Figure 4-44, (1))**.



0003514

Figure 4-44

6. Set a dial gauge on case B with tip of dial indicator gauge touching either the input pinion or support pinion. Carefully rotate shafts and measure the backlash between output gear and input shaft pinion; and output gear and support shaft pinion. Standard backlash is 0.08 - 0.16 mm (0.00314 - 0.0063 in.) **(Figure 4-44)**.

**Figure 4-45**

Note: The backlash measurement between output gear and support pinion is only for confirmation. This value is determined by parts accuracy and can not be adjusted.

- If backlash is 0.08 - 0.16 mm (0.003 - 0.006 in.), go to step 6.
 - If backlash is less than 0.08 mm (0.003 in.), decrease the shim thickness of input shaft shims. Decreasing the shim thickness by 0.1 mm (0.004 in.), increases backlash by 0.008 mm (0.0003 in.).
 - If backlash is greater than 0.16 mm (0.006 in.), increase the shim thickness of output shaft shims. Increasing the shim thickness by 0.1 mm (0.004 in.), decreases backlash by 0.008 mm (0.0003 in.).
7. Remove output shaft from case B. Reinstall the output shaft in case B with baffle plate.

Reassembly of Taper Roller Bearing Outer Races Into Case B

1. Heat case B in an oven or other way to approximately 120°C (250°F), or cool outer races with dry ice or liquid nitrogen.

⚠ WARNING

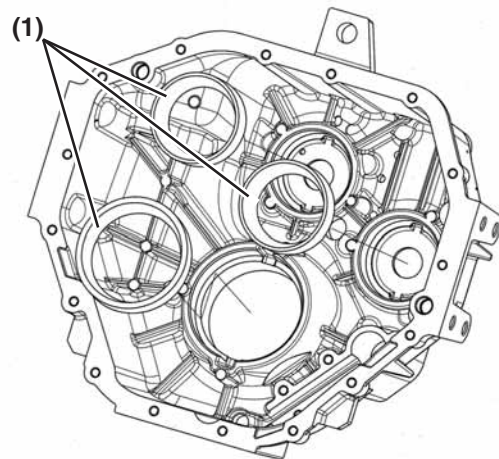


BURN HAZARD!

- Handle heated tapered roller bearing outer races with heat resistant gloves!
- Failure to comply could result in death or serious injury.

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2. Install outer races (**Figure 4-46, (1)**) into case B.
3. When case B has cooled down to ambient temperature, carefully finish installing outer races using a copper / brass punch.

**Figure 4-46**

Reassembly of Oil Suction Cover (If Removed Earlier)

1. Apply a thin coat of Threebond™ 1215, or equivalent to suction cover location on case B.
2. Place suction cover (**Figure 4-47, (1)**) onto case B.
3. Install and tighten (5) M8 suction cover bolts (**Figure 4-47, (2)**).

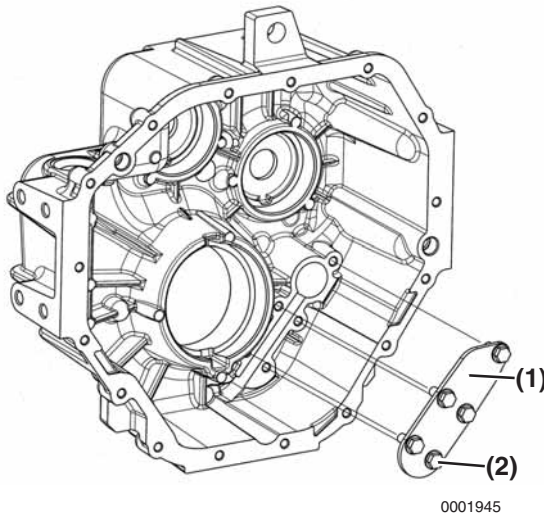


Figure 4-47

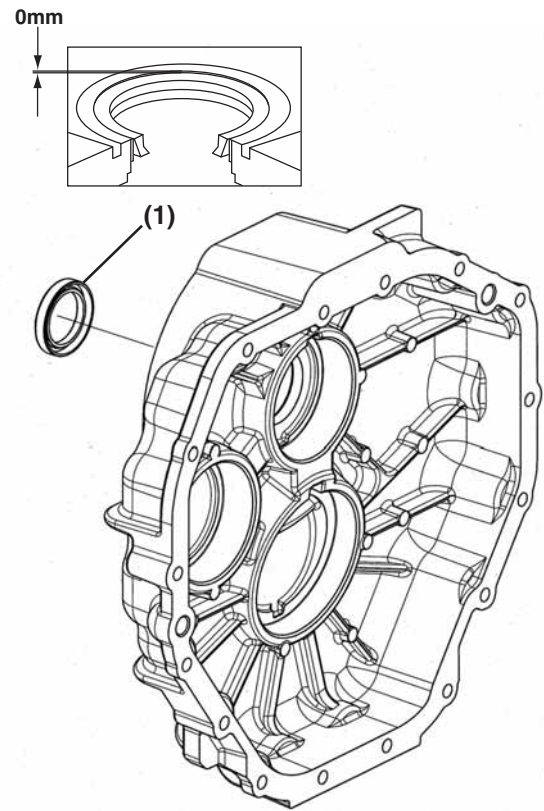


Figure 4-48

Reassembly of Oil Seals

1. Apply Shell Alvania Grease™ or equivalent to lips of input oil seal (**Figure 4-48, (1)**) and output oil seal (**Figure 4-49, (1)**).
2. Install the seals until seal is flush with case.

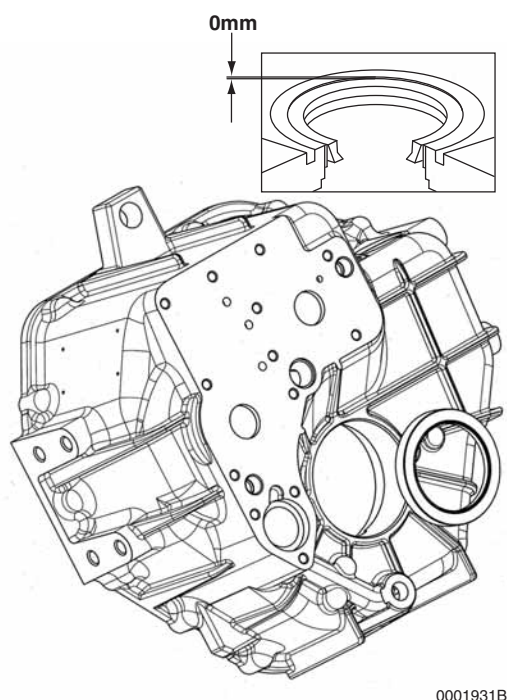


Figure 4-49

Measuring Bearing Clearance / Adjusting Bearing Preload

This procedure is required when a gear ratio or the shaft assembly is changed.

The required preload / play of bearings of the individual shafts in the housing is obtained by using shims of different thickness under the outer races of the tapered roller bearings.

Shims which have been removed during disassembly may be reused.

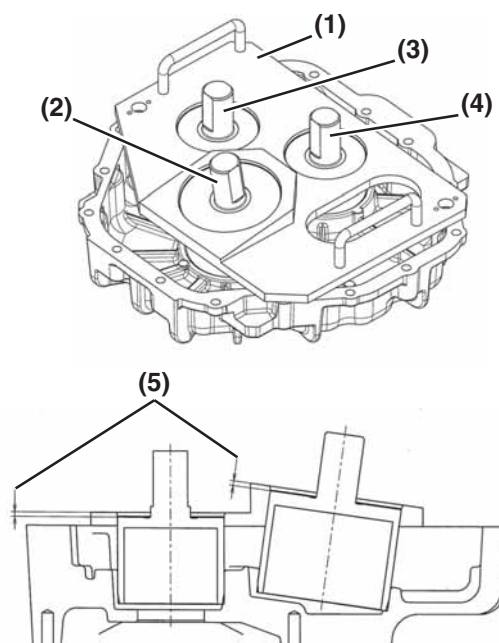
Adjustment of Bearing Preload / Play

Input	Support	Output
0.05mm Preload 0.05mm Play	0.05mm Preload 0.05mm Play	0.10mm Preload 0.00mm Play

Adjustment of Bearing Clearance

1. Set the special tool (**Figure 4-50, (1, 2, 3 & 4)**) on case A.
2. Using a dial gauge, measure the depth A of each individual master (**Figure 4-50, (5)**).
3. Set the special tool (**Figure 4-51, (1, 2, 3 & 4)**) on case B.
4. Using a dial gauge, measure the depth B of each individual master (**Figure 4-51, (5)**).
5. Calculate the required shim thickness T using the following formula.

Input Shaft	$T = A + B \pm 0.05 \text{ mm}$
Support Shaft	$T = A + B \pm 0.05 \text{ mm}$
Output Shaft	$T = A + B + 0 - 0.1 \text{ mm}$



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Figure 4-50

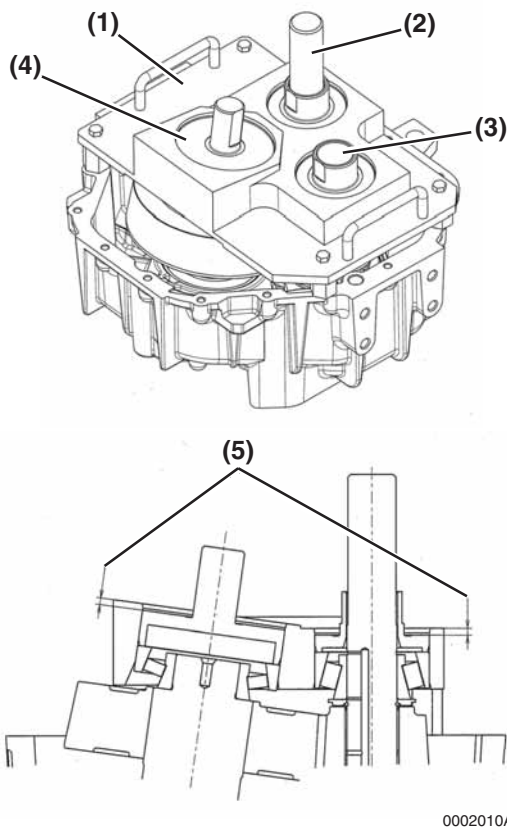


Figure 4-51

Reassembly of Gear Set Into Housing

1. Install baffle.
2. Clean housing mating surfaces with an oilstone.

CAUTION

Keep dirt out of marine gear housing. Dirt may shorten the life of the marine gear and cause it to operate improperly.

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Reassembly of Tapered Roller Bearings Outer Races Into Case A

1. Use the required shim thickness (**Figure 4-52, (2)**) determined in *Bearing Preload / Play Adjustment* and *Bearing Clearance Adjustment*.
2. Heat case A (engine side case) in an oven or other way to approximately 120°C (250°F) or cool outer races with dry ice or liquid nitrogen.

WARNING

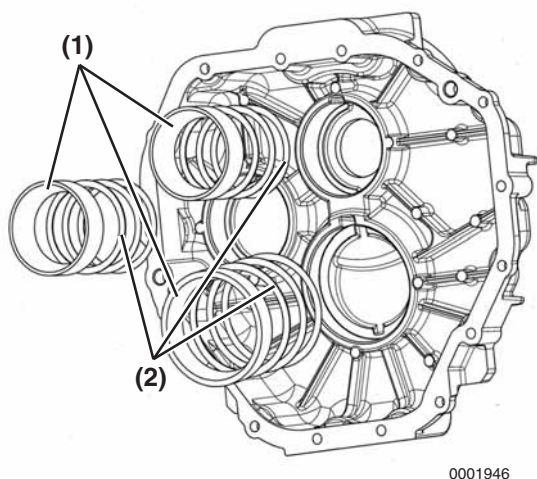


BURN HAZARD!

- Handle heated tapered roller bearing outer races with heat resistant gloves!
- Failure to comply could result in death or serious injury.

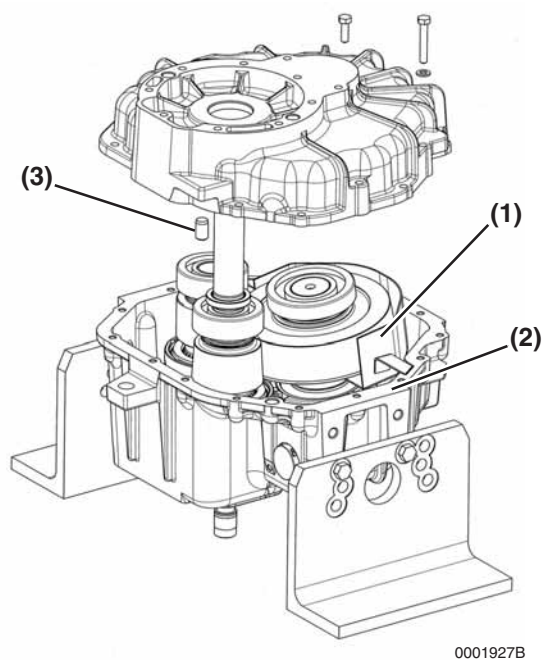
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3. Insert shims and outer races (**Figure 4-52, (1)**) into case A.
4. When case has cooled down to ambient temperature, carefully finish installing outer races using a copper / brass punch.

**Figure 4-52**

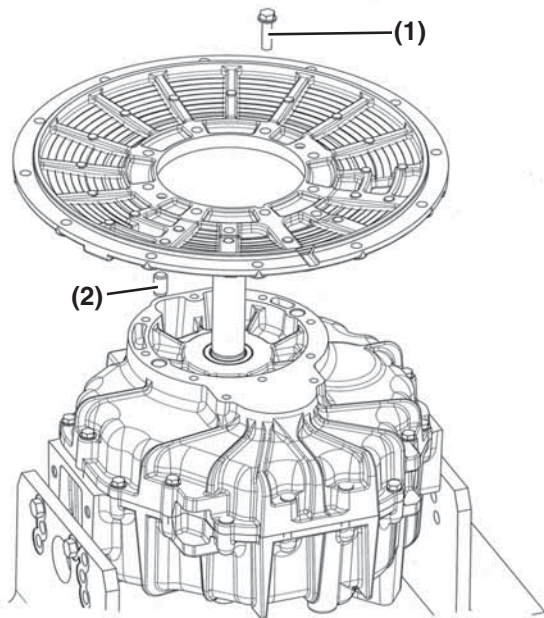
Final Assembly of Cases

1. Align tabs and install baffle (**Figure 4-53, (1)**).
2. Using Shell Alvania Grease™ or equivalent, fill space between seal and dust lips of shaft seal rings.
3. Apply a thin coat of Threebond™ 1215 or equivalent on mating face of case B (**Figure 4-53, (2)**).
4. Install parallel pins (**Figure 4-53, (3)**) with large chamfer end facing up.

**Figure 4-53**

Reassembly of Mounting Flange

1. Install (2) locating pins (**Figure 4-54, (2)**).
2. Install (10) M10x35 hex head bolts (**Figure 4-54, (1)**) with 14 mm socket wrench.

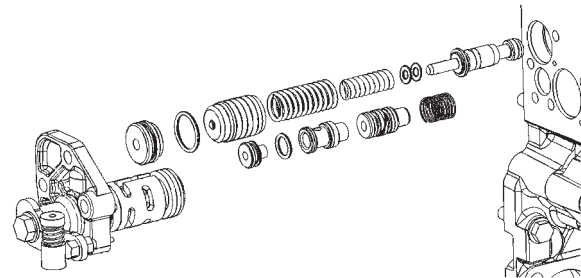


0001926

Figure 4-54

Reassembly of Valves

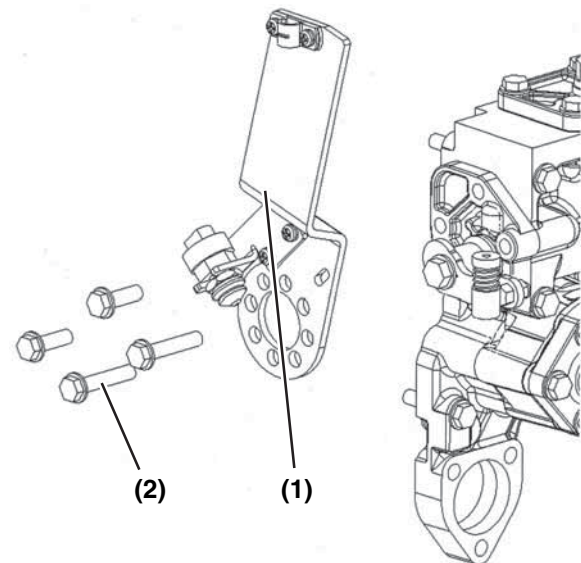
1. Install valves to case plate (**Figure 4-55**).



0003516

Figure 4-55

2. If it is necessary, adjust the shifting pressure by increasing or decreasing shims (increasing the shim thickness by 0.1 mm (0.0039 in.), shifting pressure rise by about 0.7 MPa (101.5 psi)).
3. Install bracket (**Figure 4-56, (1)**).



0003517

Figure 4-56

4. Install and tighten four hex bolts (**Figure 4-56, (2)**).

Reassembly of Case Plate

1. Remove repair stand, install the mounting feet.
2. Install parallel pins (**Figure 4-57, (1)**) with large chamfer end facing case plate.
3. Place lubricating pressure relief (**Figure 4-57, (2)**) valve on housing (not shown in line drawing).
4. Replace gasket (**Figure 4-57, (3)**) on housing.
5. Slide case plate carefully onto input shaft and support shaft.
6. Install and tighten bolts to specified torque.

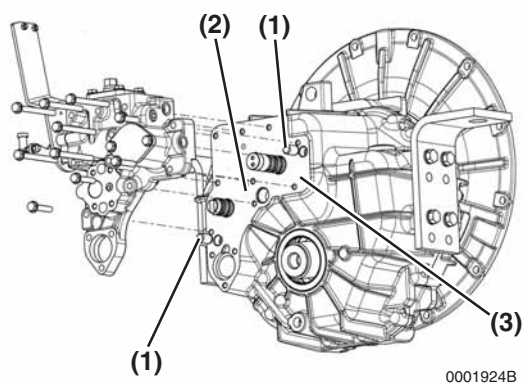


Figure 4-57

Reinstall Oil Filter

1. Check seal for damage and filter for wear. Replace if necessary.
2. The oil filter (**Figure 4-58, (1)**) must be washed with clean oil whenever the oil is changed.
3. Install strainer, spring, gasket, and cover with (3) M8x40 bolts.

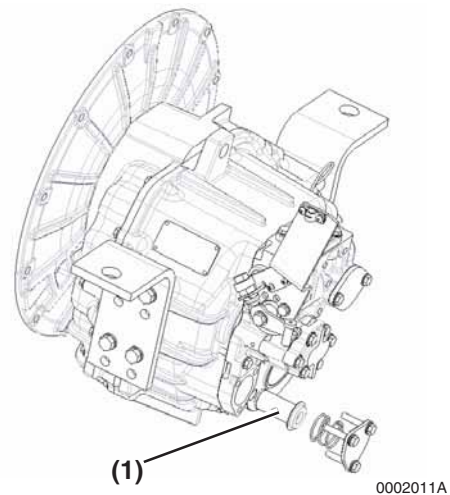
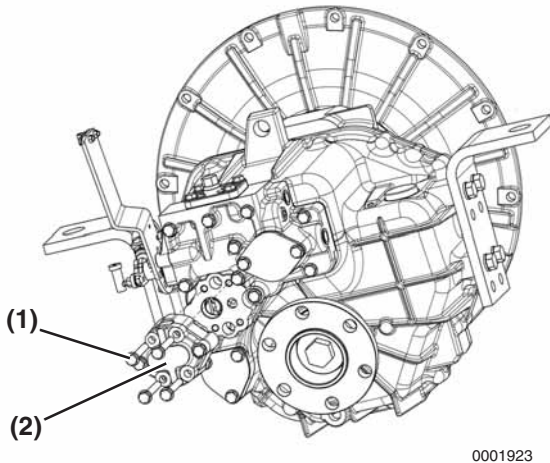


Figure 4-58

Reinstall Hydraulic Oil Pump

1. Install oil pump (**Figure 4-59, (2)**).
2. Install (4) M8x65 hex head bolts (**Figure 4-59, (1)**).



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Figure 4-59

Reassembly of Output Coupling

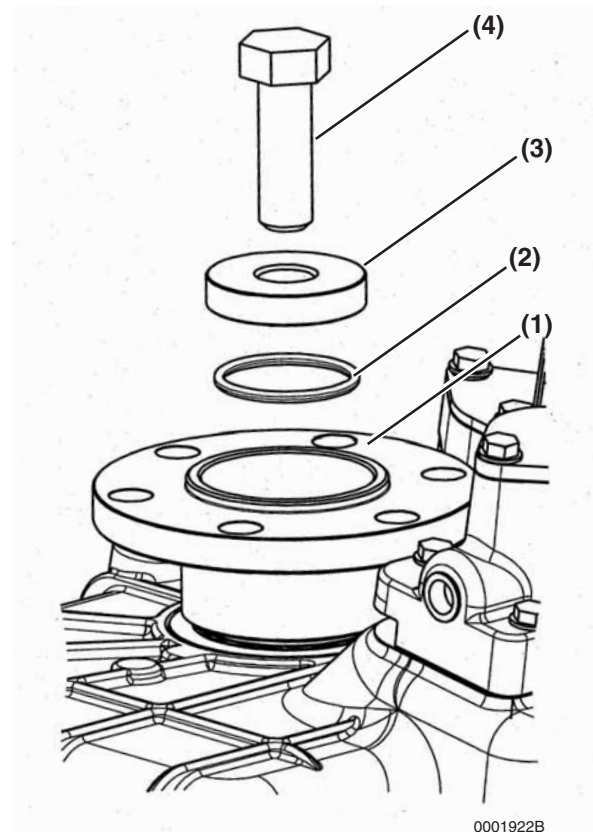
1. Remove O-ring from coupling before heating coupling.
2. Heat output coupling to 120°C (250°F) (**Figure 4-60, (1)**).

⚠ WARNING
<p>BURN HAZARD!</p> <ul style="list-style-type: none"> • Handle heated output coupling with heat resistant gloves! • Failure to comply could result in death or serious injury.

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3. Press output coupling onto shaft using M20x60 retaining bolt (**Figure 4-60, (4)**).

4. Remove bolt. When output coupling has cooled down to ambient temperature, lubricate O-ring (**Figure 4-60, (2)**) with grease and insert into output coupling.
5. Add anti-seize compound to bolt. Finish tightening output coupling down on output shaft with bolt (**Figure 4-60, (4)**) and coupling plate (**Figure 4-60, (3)**).
6. Tighten bolt to 401-441 N·m (295-325 ft-lb).



0001922B

Figure 4-60

FILLING MARINE GEAR WITH OIL

Recommended Oil (Type of Oil)

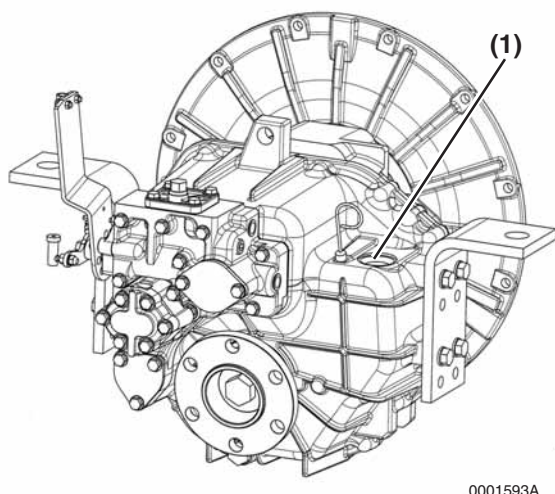
API (American Petroleum Institute) service grade: class CD or CF.

Viscosity: SAE 30

Note: NEVER use multi-grade oil or mix oil types. Single-grade oil must be used.

Capacity: 2.8 L (3.0 qt)

1. Remove the oil cap (**Figure 4-61, (1)**). Fill with the following quantities of oil, and add the amount required for cooler and pipelines.
2. After filling the marine gear with oil, reinstall the oil cap and hand-tighten. Over-tightening may damage the cap.



0001593A

Figure 4-61

CHECKING OIL LEVEL

WARNING**SEVER HAZARD!**

- NEVER service the marine gear while under tow or if the engine is running at idle speed. The propeller may rotate under these circumstances.
- Failure to comply could result in death or serious injury.

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CAUTION

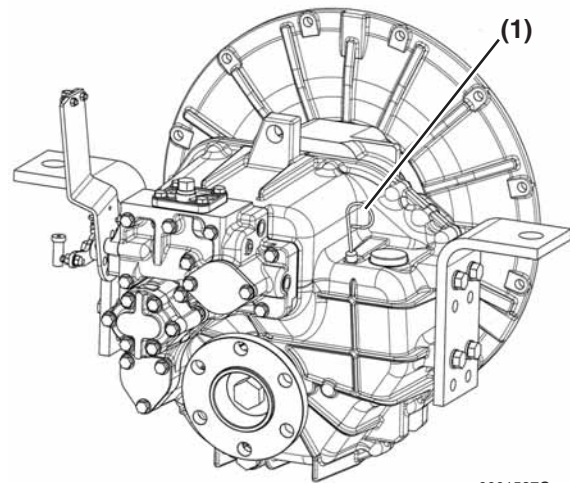
- Only use the marine gear oil specified. Other marine gear oils may affect warranty coverage, cause internal marine gear components to seize and / or shorten marine gear life.
- Prevent dirt and debris from contaminating marine gear oil. Carefully clean the oil plug and dipstick and the surrounding area before you remove either one.
- NEVER mix different types of marine gear oil. This may adversely affect the lubricating properties of the marine gear oil.
- NEVER overfill. Overfilling may result in internal damage.

0000005enTrans

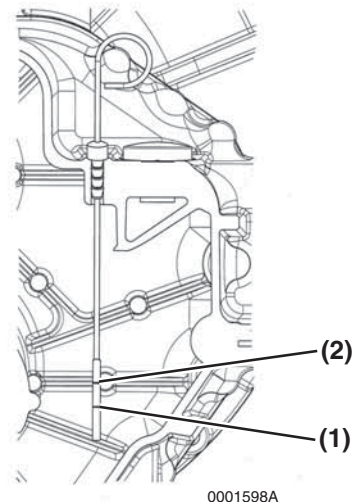
Always check oil level before operating the marine gear. Marine gear oil level may be checked in cold or hot condition.

1. Remove dipstick (**Figure 4-62, (1)**) and wipe with clean cloth.
2. Fully reinsert dipstick.
3. Remove dipstick. The oil level should be between the upper (**Figure 4-63, (2)**) and lower (**Figure 4-63, (1)**) lines on dipstick.

4. Fully reinsert dipstick



0001587C

Figure 4-62

0001598A

Figure 4-63

5. Move the shift lever to NEUTRAL position.
6. Start the engine. Let the engine run at idle with the shift lever in the NEUTRAL position for several minutes. This will ensure the oil is distributed to all pipelines, oil cooler and marine gear oil passages.

CAUTION

After you add marine gear oil, run the engine for several minutes and shut it down. Wait at least 10 minutes to check the marine gear oil level. This allows the oil to drain back into the sump, otherwise, you may overfill the marine gear with oil.

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5. Check oil level. If necessary, add oil until the level reaches the upper mark on the dipstick. Check the oil level again after operating the marine gear for a short period of time.

7. Stop the engine. WAIT AT LEAST 10 MINUTES for the oil to drain back into the sump.
8. Check the oil level. If necessary, add oil until the level reaches the upper mark on the dipstick. Check the oil level again after operating the marine gear for a short period of time.

TRIAL RUN

1. Perform a trial run after filling marine gear with oil.
2. Move the shift lever to the NEUTRAL position.
3. Start the engine. Let the engine idle with the shift lever in the NEUTRAL position for several minutes. This will ensure the oil is distributed to all pipelines and the oil cooler.

CAUTION

After you add marine gear oil, run the engine for several minutes and shut it down. Wait at least 10 minutes to check the marine gear oil level. This allows the oil to drain back into the sump, otherwise, you may overfill the marine gear with oil.

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4. Stop the engine. WAIT AT LEAST 10 MINUTES for the oil to drain back into the sump.

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Section 5

TROUBLESHOOTING

In case of trouble, check first if all items of the mounting and operating instructions have been completed. The subsequent tables will assist you in troubleshooting.

No.	Problem	Possible Cause	Countermeasure
1	Transmission cannot be shifted	Shifting lever is loose.	Tighten clamping bolt on shifting lever.
		Remote control does not permit lever travel required for testing.	Lift remote control off, if gears can be shifted by hand, correct remote control.
		Remote control faulty.	Repair remote control.
		No shifting pressure available.	Refer to No.7.
2	Delayed shift time	Shift linkage misadjusted; not allowing full engagement.	Lift remote control off; if gears can be shifted by hand, correct remote control. If the transmission cannot be shifted correctly by hand, replace the control block.
3	Clutch is slipping, i.e. propeller speed too low for engine speed.	Inadmissible oil used.	Drain oil, refill with prescribed oil, flush transmission while engine runs in neutral position, drain oil, refill transmission.
		Oil contains water.	Refer to No.9.
		Shifting pressure too low.	Refer to No.6.
		Wear on clutch disks.	Disassemble transmission, replace clutch disks.
		Piston rings in clutch are damaged.	Disassemble transmission, replace clutch.

TROUBLESHOOTING

No.	Problem	Possible Cause	Countermeasure
4	Transmission locked in gear	Seal ring on input shaft or support shaft in case plate is faulty.	Remove case plate, replace seal ring, if case plate is worn, replace.
		Warped disks due to overheating of slipping clutch.	Refer to No.3.
		Plain bearings on input or support shaft have failed.	Disassemble transmission, repair if possible or use substitute transmission.
5	Output shaft turns in neutral position.	Rotary valve in casing is worn.	Replace rotary valve.
		Faulty plain bearing on input or support shaft.	Disassembly transmission and input or support shaft, replace bearing concerned and other damaged parts.
		Warped disks due to overheating of slipping clutch.	Refer to No.3.
6	Shifting pressure too low	Oil strainer clogged.	Wash strainer or replace fine one.
		Oil level in transmission.	Top up with oil; In case of oil loss check transmission, cooler and pipelines for leakage; and remedy in the same way; also refer to No.10 through No.13.
		Oil pump is worn out.	Replace oil pump.
		Spring in shifting pressure relief valve is broken.	Replace spring.
		Seal rings on input shaft or support shaft are faulty.	Remove case plate, replace seal ring, if case plate is worn, replace likewise.
		Throttle valve for shifting pressure is broken.	Replace throttle valve.
		Piston rings in clutch are faulty.	Disassemble transmission. Replace clutch.
		Choke port at modulator valve obstructed by contamination.	Wash the modulator valve.

TROUBLESHOOTING

No.	Problem	Possible Cause	Countermeasure
7	No shifting pressure available	Direction of engine rotation does not agree with arrow on transmission.	Replace with engine of correct rotation.
		No oil in the transmission.	Refill with oil.
		Strainer is dirty.	Replace fine strainer.
		Oil level in transmission is too low.	Top up with oil; In case of oil loss check transmission, cooler and pipelines for leakage; and remedy in the same way. Also refer to No.10 through No.13.
		Oil pump is worn out.	Replace oil pump.
		Spring in shifting pressure relief valve is broken.	Replace spring.
		Throttle valve for shifting pressure is broken.	Replace throttle valve.
8	Excessive oil temperature	Excessive oil in transmission.	Remove excessive oil with commercial suction pump.
		Oil cooler is dirty on water side.	Clean oil cooler on water side.
		Worn oil pump.	Replace oil pump.
		Seal rings on input shaft or support shaft are faulty.	Remove case plate, replace seal ring. If case plate is worn, replace likewise.
		Clutch is slipping.	Refer to No.3.
		Clutch does not open completely due to worn disc support.	Dismount transmission and coupling. Replace inner disc support and / or clutch.
9	Water in the oil, oil looks milky	Oil cooler faulty.	Repair leakage at cooler or replace cooler.
		High water level in engine compartment, water entering through output shaft seal.	Remedy cause for water level in engine compartment change transmission.

TROUBLESHOOTING

No.	Problem	Possible Cause	Countermeasure
10	Oil leakage at output shaft	Breather clogged with paint or dirt.	Remove paint or dirt from breather.
		Shaft seal faulty.	Disassemble transmission. Replace seal. If seal location on output shaft is worn-seal lip should be mounted offset.
11	Oil leakage at breather	Excessive oil in transmission.	Pump out excessive oil.
12	Oil leakage at joints	Bolts are not tight.	Tighten bolts with prescribed torque.
		Seals on bolts have been damaged.	Replace seals, tighten bolts used several times with prescribed torque.
		Mating faces are contaminated, no surface seal applied.	Unscrew housing half, finish mating faces with oilstone or finishing file, apply surface seal. Assemble transmission, tighten bolts to prescribed torque.
13	Transmission noise becomes louder	Oil level too low so that pump sucks in air.	Top up with oil to marking on dipstick.
		Damage starting on flexible coupling due to misalignment between engine and transmission.	Replace flexible coupling. Check alignment between engine and transmission.
		Beginning damage of bearings in transmission, e.g. due to torsional vibrations, running without oil, overload, wrong alignment of transmission, excessive engine output.	Disassemble transmission, replace bearings of damaged and other faulty parts. Find causes and remedy.
		Beginning damage of gearings, e.g. due to torsional vibrations, running without oil, overload.	Disassemble transmission, remove faulty parts.
		Oil suction cover in transmission has come loose.	Disassemble transmission, secure oil suction cover.

TROUBLESHOOTING

No.	Problem	Possible Cause	Countermeasure
14	Chattering transmission noise mainly at low engine speed	The engine or propeller generate torsional vibrations in the drive unit which produce a (chattering) noise in the transmission.	Mount a specified damper between engine and transmission (recommended damper: Type CF-R-136-011-61106-S2 by CENTA. Parts No.177524-03911). Otherwise analyze the torsional vibrations to find out the proper propeller shaft and propeller (refer to recommended propeller shaft and propeller in operation manual).
		Misaligned jack shaft on input or output.	Mount and align jack shaft strictly according to instructions issued by jack shaft manufacturer.

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